



male



1st instar



Passiflora (Passifloraceae)

Scea auriflamma
(Notodontidae:
Dioptinae) SE Brazil



egg



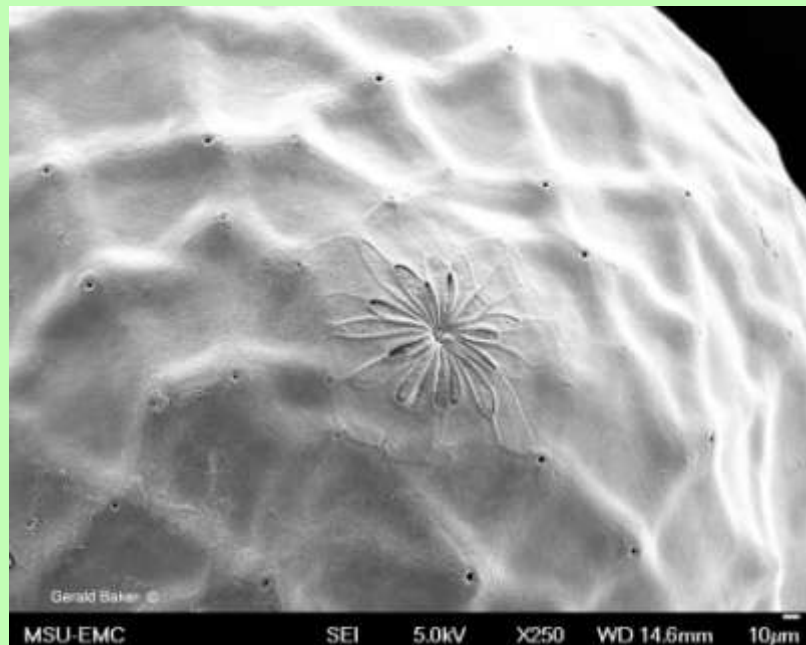
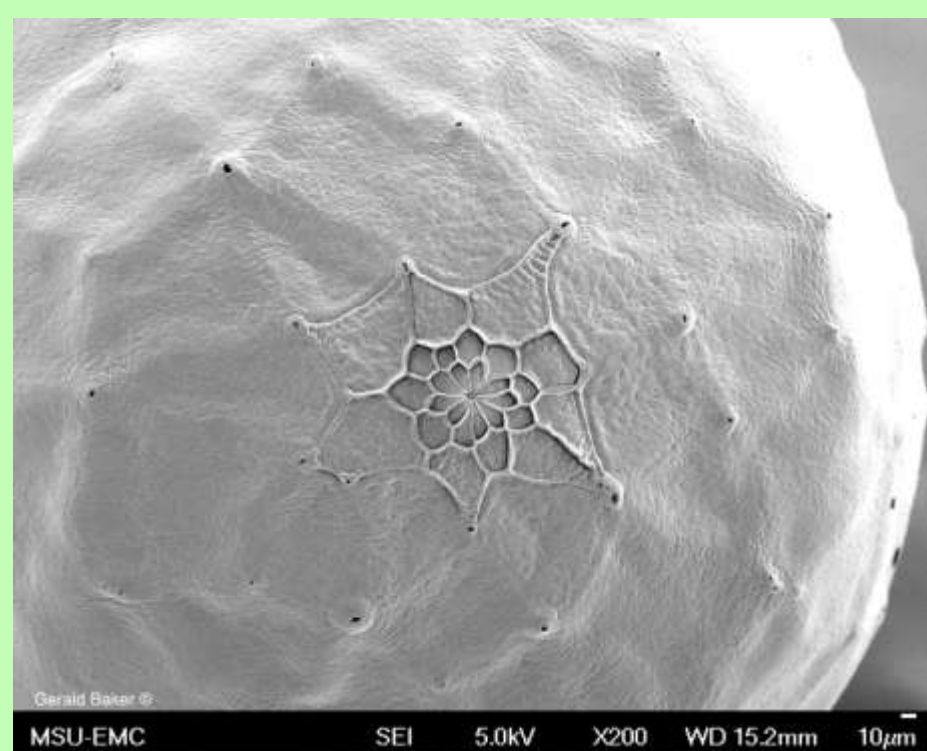
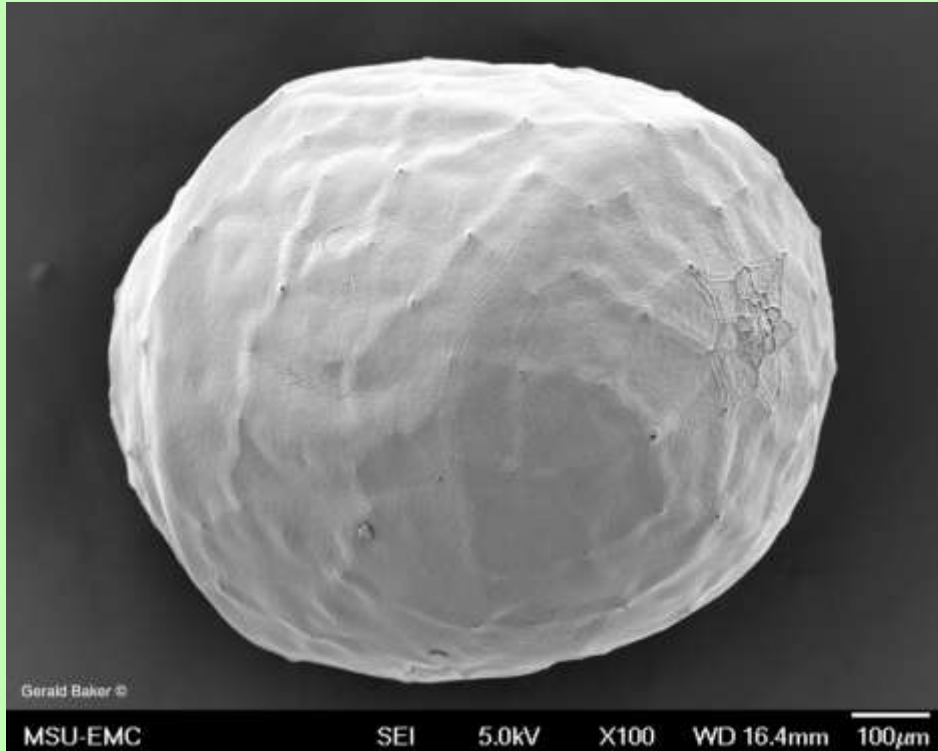
pupa

5th (ultimate) instar



female





EGG MORPHOLOGY (*Cactoblastis*; Pyralidae)

- The surface is covered with regularly spaced *aeropyles*, which aid in oxygen uptake.
- A rosette-like area at the top, called the *micropyle*, allows for passage of sperm into the egg.



male



female



Alchornea
(Euphorbiaceae)



egg

Catonephele numilia (Nymphalidae)



1st instar on frass
chain



2nd instar



newly molted 4th instar



5th instar



chrysalis

Catonephele numilia
(Nymphalidae: Biblidinae)
ultimate instar
SE Brazil



LEPIDOPTERA LARVAL MORPHOLOGY

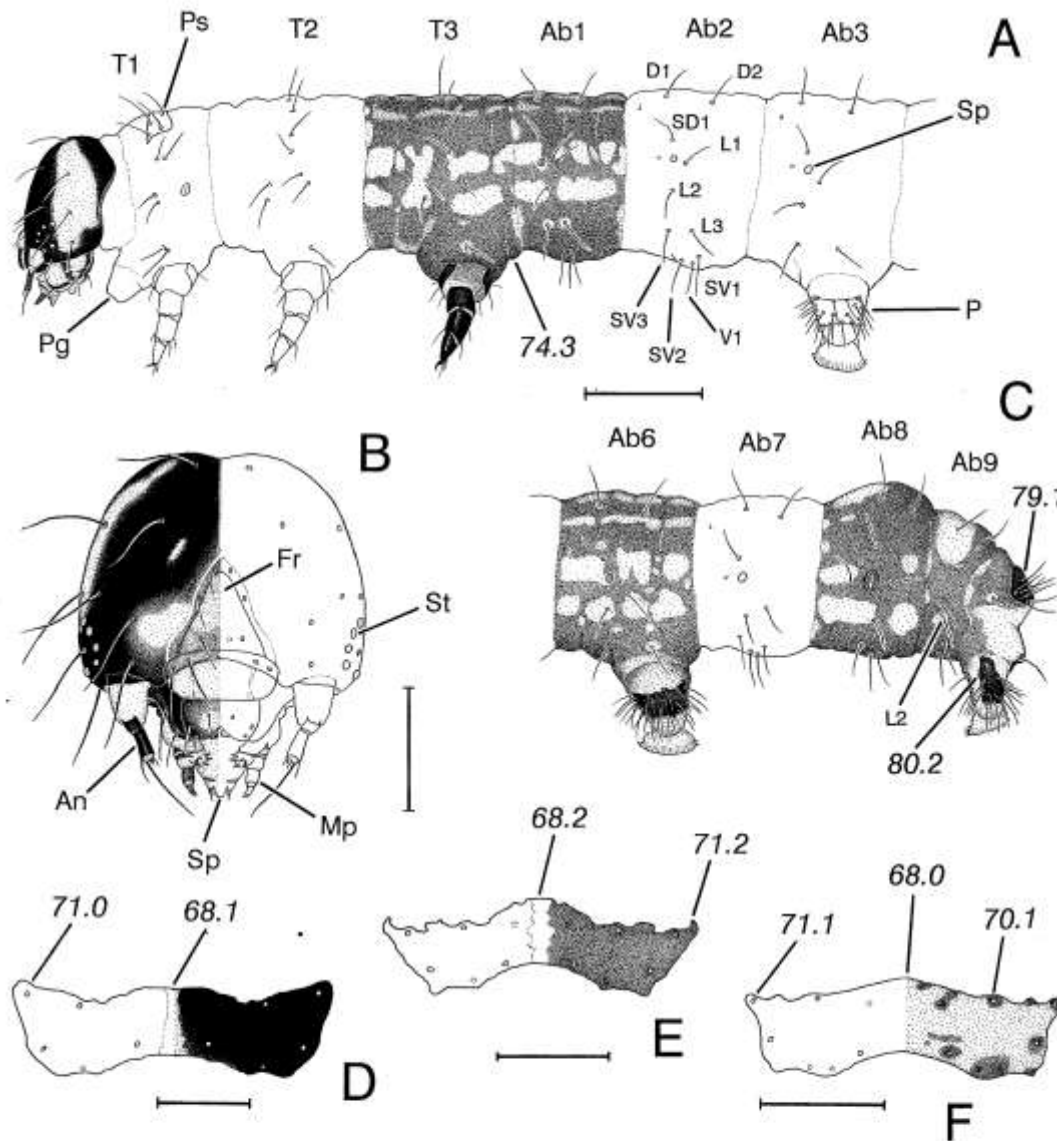
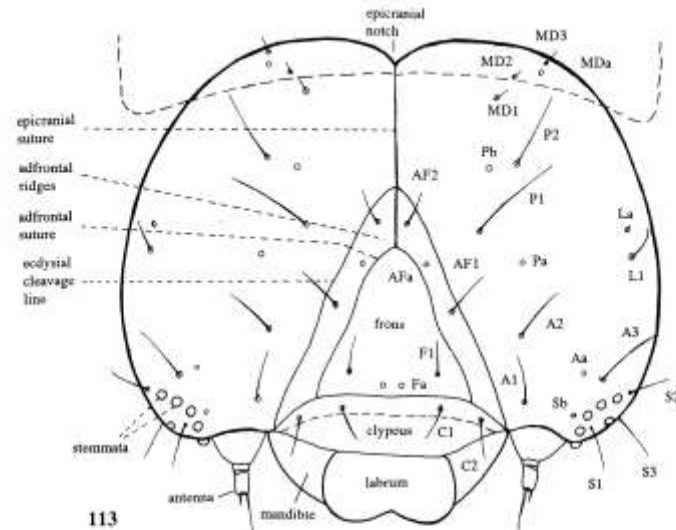


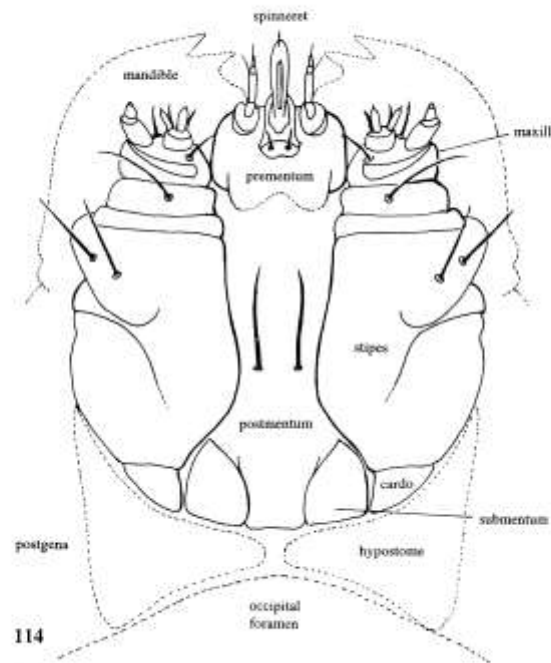
Figure 18. Final instar larvae of Josiini (Characters 68-82). A, Head, thorax and A1-A3 of *Thirrida superba* in lateral view; B, Head of *T. superba* in frontal view; C, Segments A6-A10 of *T. superba* in lateral view. D, Prothoracic shield of *T. superba*, dorsal view; E, Prothoracic shield of *Josia insinera*, dorsal view; F, Prothoracic shield of *J. striata*, dorsal view. Scale bars: A, C = 2.0 mm; B, D-F = 1.0 mm. Ab = abdominal segment; An = antenna; D = dorsal seta; Fr = frons; L = lateral seta; Mp = maxillary palpus; P = proleg; Pg = prothoracic gland; Ps = prothoracic shield; SD = subdorsal seta; Sp = spiracle; St = stemmata; SV = subventral seta; T = thoracic segment; V = ventral seta.

- a relatively simple, uniform structure across most groups.
- a pair of spiracles on each segment.
- segmented legs on all three thoracic segments.
- a prothoracic shield on T1.
- prolegs on A3-A6 and A10, these bearing crochets; proleg loss in certain groups.
- a conservative arrangement of primary setae on all tagma.
- a standardized setal nomenclature (Hinton, 1946): dorsal, subdorsal, lateral, subventral, and ventral setae.

Larval morphology

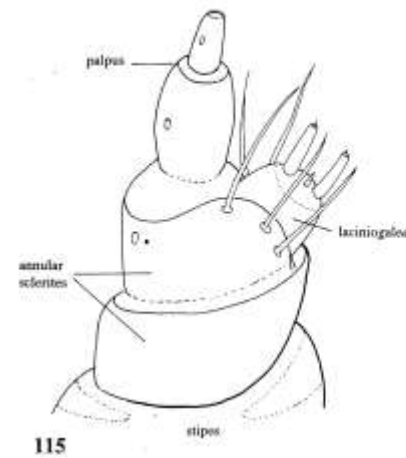


113

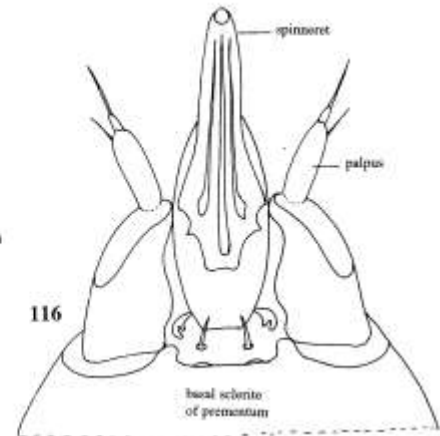


114

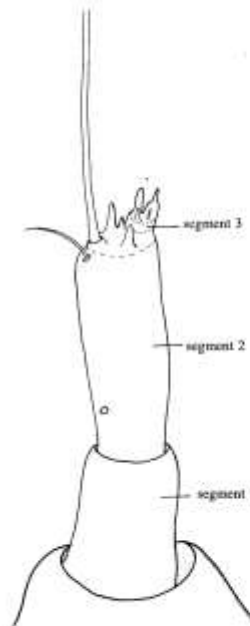
Figs 113, 114. Larval head (diagrammatic). 113, anterior view; 114, ventral view. (113, after Peterson, 1962; 114, after Bourgogne, 1951.)



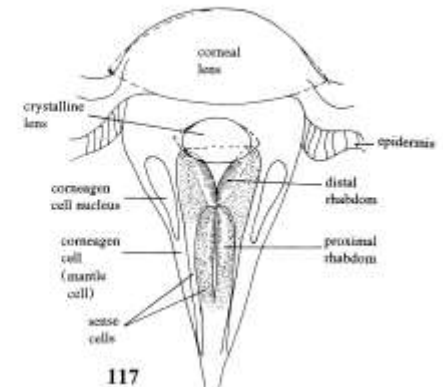
115



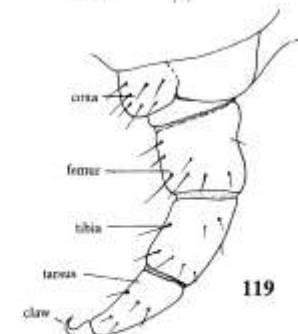
116



118

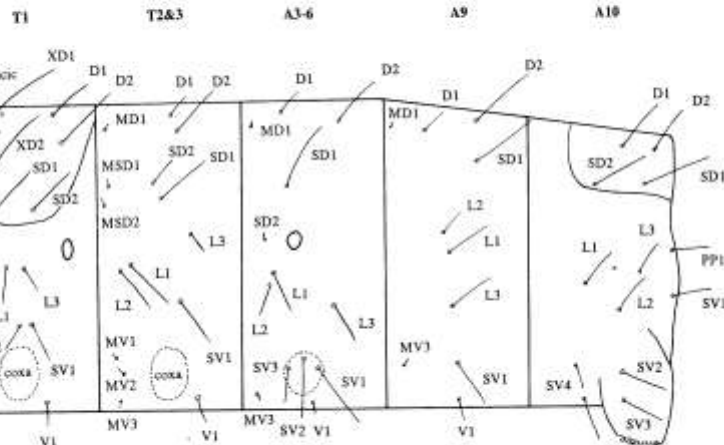
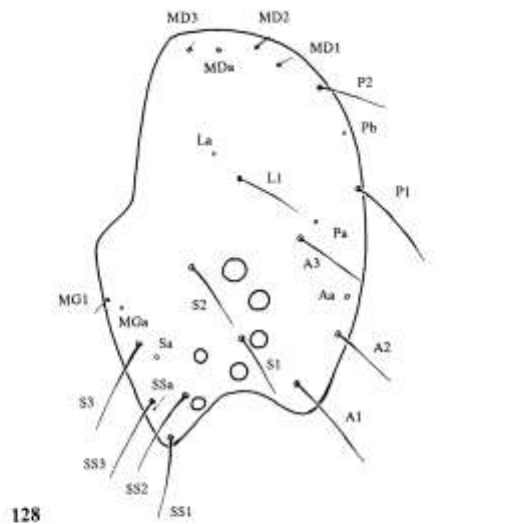


117

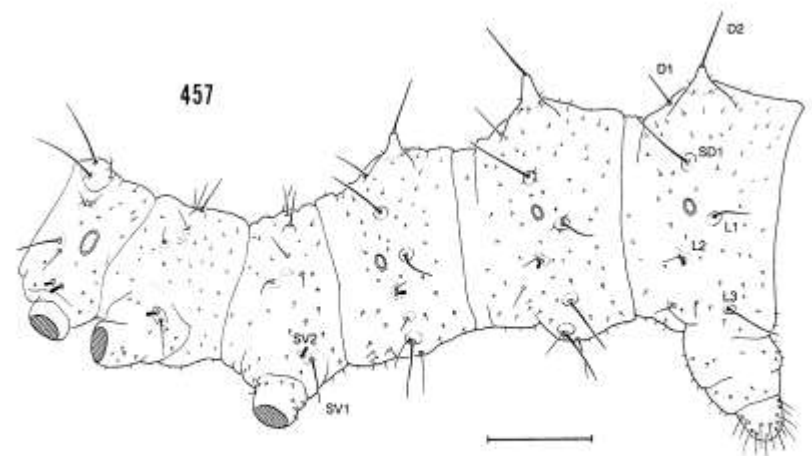
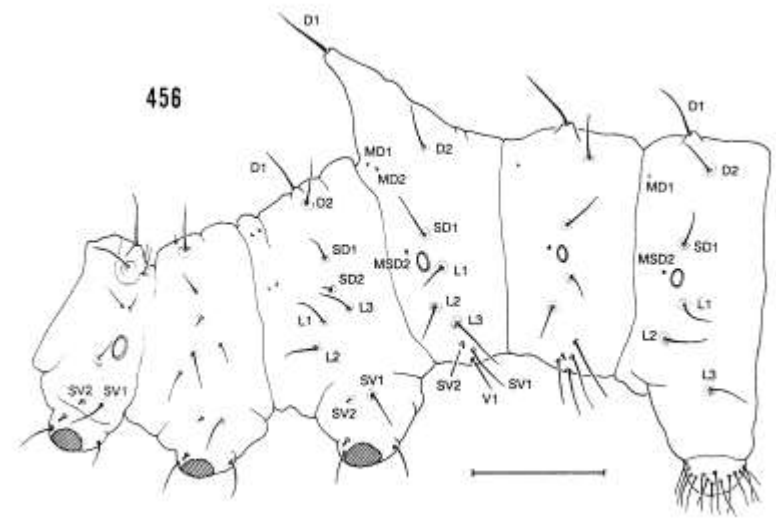


119

Figs 115–119. Larval morphology (diagrammatic). 115–118, head morphology. 115, left maxilla; 116, labium, ventral view; 117, stemma of *Pyreharctia isabella* (Arctiidae); 118, antenna; 119, thoracic leg. (115, 116, after Bourgogne, 1951; 117, after Dethier, 1963; 118, 119, after Peterson, 1962.)



Figs 128, 129. Larval morphology showing arrangement of primary setae (chaetotaxy). 128, head, lateral view; 129, thorax and abdomen. (128, after Hinton, 1946a, with nomenclature as modified by Stehr, 1987.)



Figs. 456, 457. Thoracic and first three abdominal segments of larval Notodontidae in lateral view; thoracic legs and planta of proleg not shown. 456. *Schizura unicornis*. 457. *Cnethodonta griseus*. For key to symbols see figures 449–451. Scale lines = 2.0 mm.

Setal maps are extremely useful for family and subfamily level identification; patterns are conserved across major groups.

Example: In Prominent Moths (family Notodontidae) the subfamily Heterocampinae (900 spp.) is defined by presence of 2 SV setae on T1--T3.



Adelpha bredowii, the Arizona Sister (Nymphalidae: Limenitidinae)

Willmott, K. R. 2003. The Genus *Adelpha*: its Systematics, Biology and Biogeography (Lepidoptera: Nymphalidae: Limenitidini). Gainesville, Scientific Publishers. viii + 322 pp.

- One of the largest butterfly genera with over 85 species.
- Distributed from SE Arizona to southern South America.



Tibouchina (Melastomataceae)



chrysalis



egg



Adelpha serpa (SE Brazil)



1st instar on frass chain



Ultimate instar



Sabicea
(Rubiaceae)



chrysalis

Adelpha viola (Brazil)



1st instar on
frass chain



Ultimate instar



From: Packard, A.S. (1895) Family Notodontidae.
 Memoirs of the National Academy of Sciences, 7: 390
 pp.

Josia insincera



Nystalea ocellata



Lirimiris fascis



Crinodes besckei



Bardaxima perses



Rosema deolis





Cerura dandon Druce (Costa Rica)
(subfamily Cerurinae)



- larval A10 prolegs modified into “stemapods”.
- apex of stemapod bears an eversible gland.
- gland is everted in response to low frequency sound (White et al., 1983).

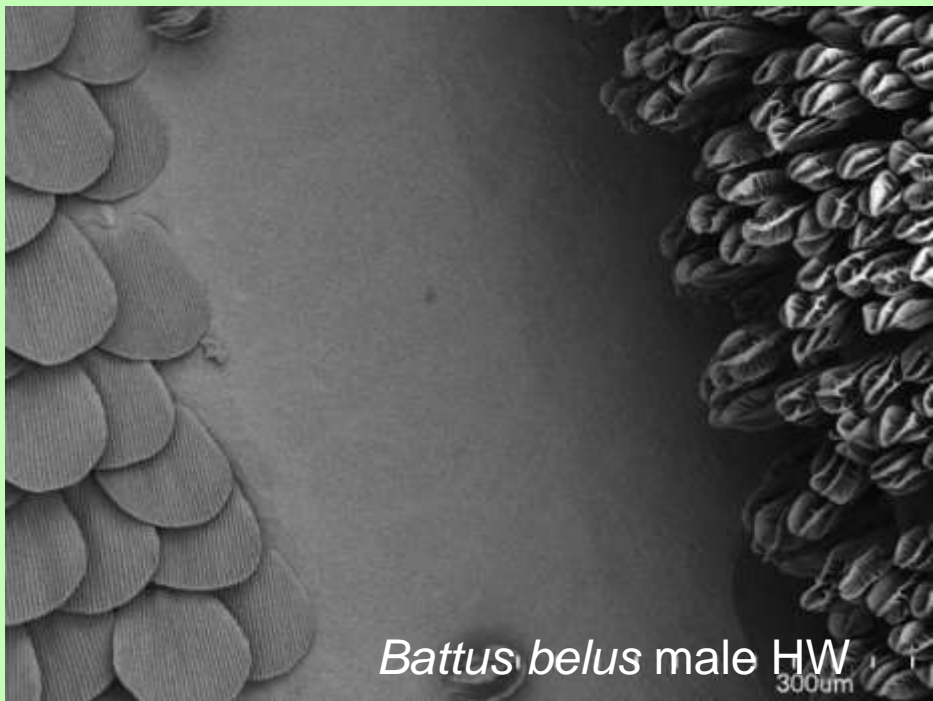




Battus philenor (Papilionidae)



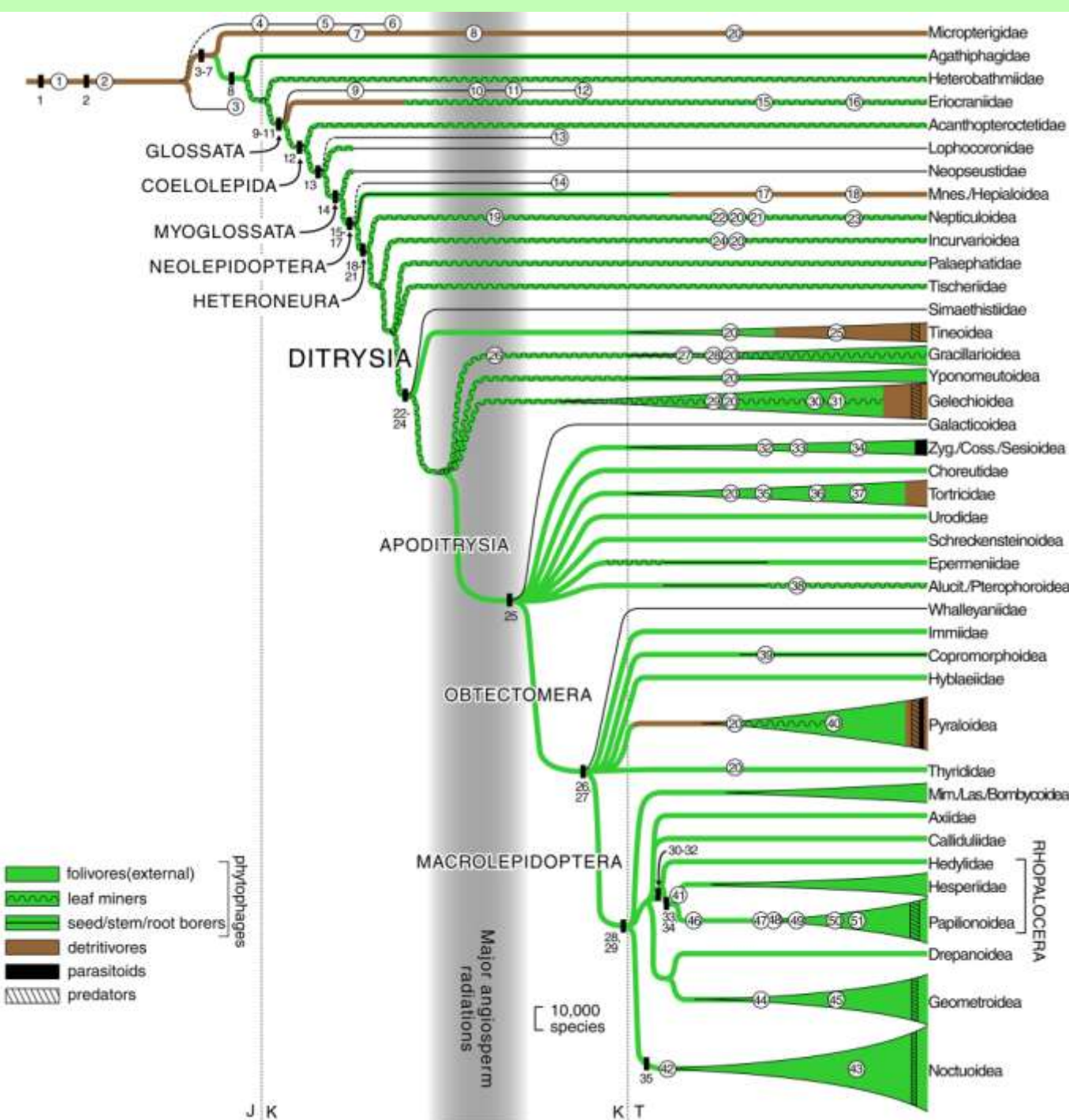
B. philenor
HW androconia



Battus belus male HW



B. belus
HW androconia



Phylogeny of the Lepidoptera from: Grimaldi & Engel (2005) *Evolution of the Insects*.

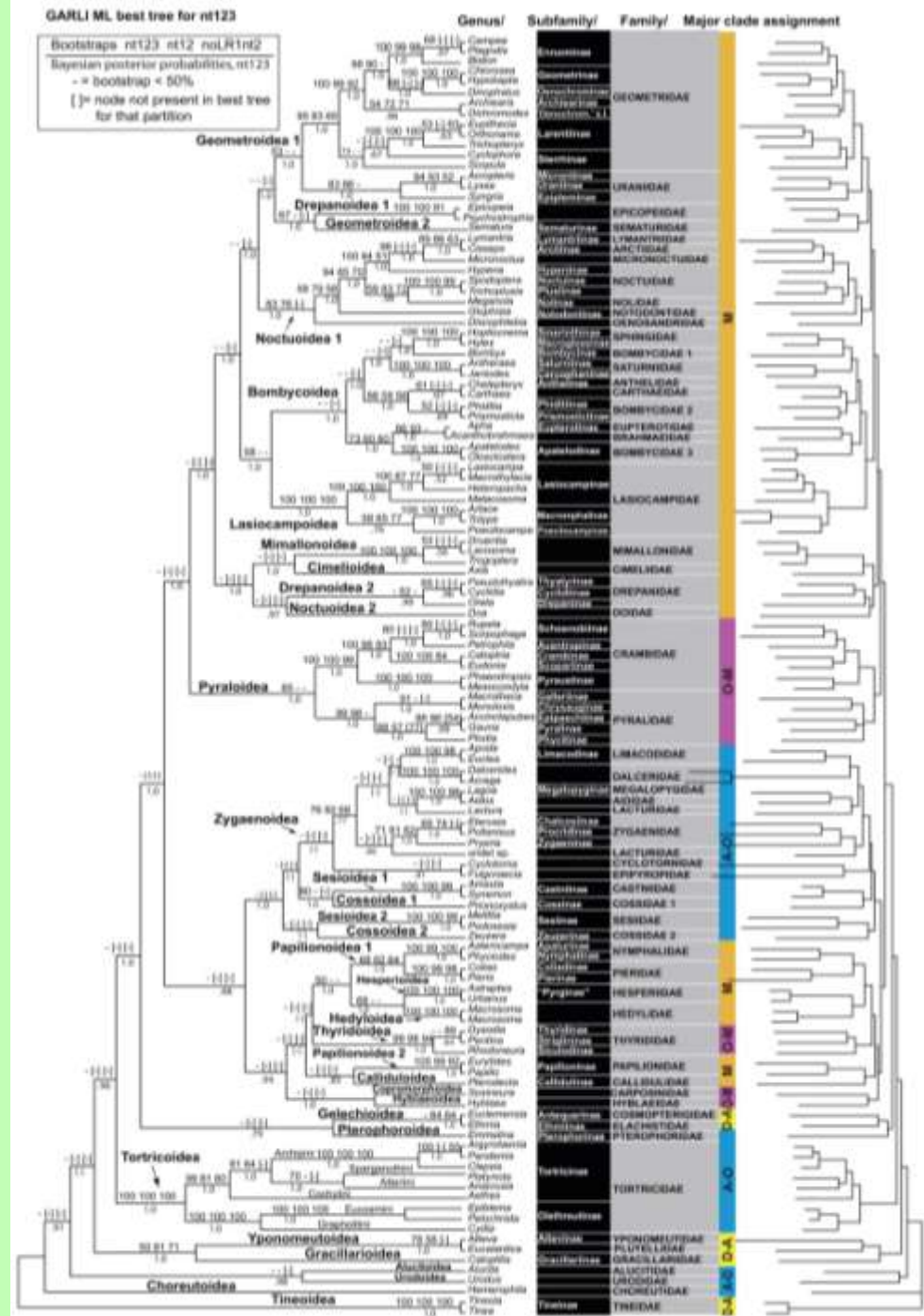
- Ditrysia contains 98% of Lepidoptera species.

- relationships within Ditrysia are poorly understood.

- clade “Macrolepidoptera” is weakly supported.

From: Regier et al. (2009) Toward reconstructing a phylogeny for advanced moths and butterflies (Lepidoptera: Ditrysia). BMC Evolutionary Biology, 9: 280.

- 123 species representing 27 of 33 superfamilies.
- 6867 bp DNA from 5 protein-coding genes.
- weak support along the entire backbone of the tree.
- Noctuoidea and Geometroidea are sister-groups.
- Butterflies are the sister-group to the Zygaenoidea.



How many Lepidoptera? There are currently 260,000 described species; estimated total ~ 500,000 spp. (Kristensen et al., 2007).

Major superfamilies of the “Macrolepidoptera”



Papilionoidea: 17,500 described species (5,000 skippers); 5% undescribed; estimated total ~ 18,500 spp.



Geometroidea: 45,000 described species; 50-60% undescribed; estimated total ~ 100,000 spp.



Noctuoidea: 70,000 described species (largest superfamily in the Lepidoptera); 50-60% undescribed; estimated total ~ 150,000 spp.

Rhetus dysonii male
(Cusco, Peru)



Clubbed antennae in butterflies;
monographed by Karl Jordan (1896)

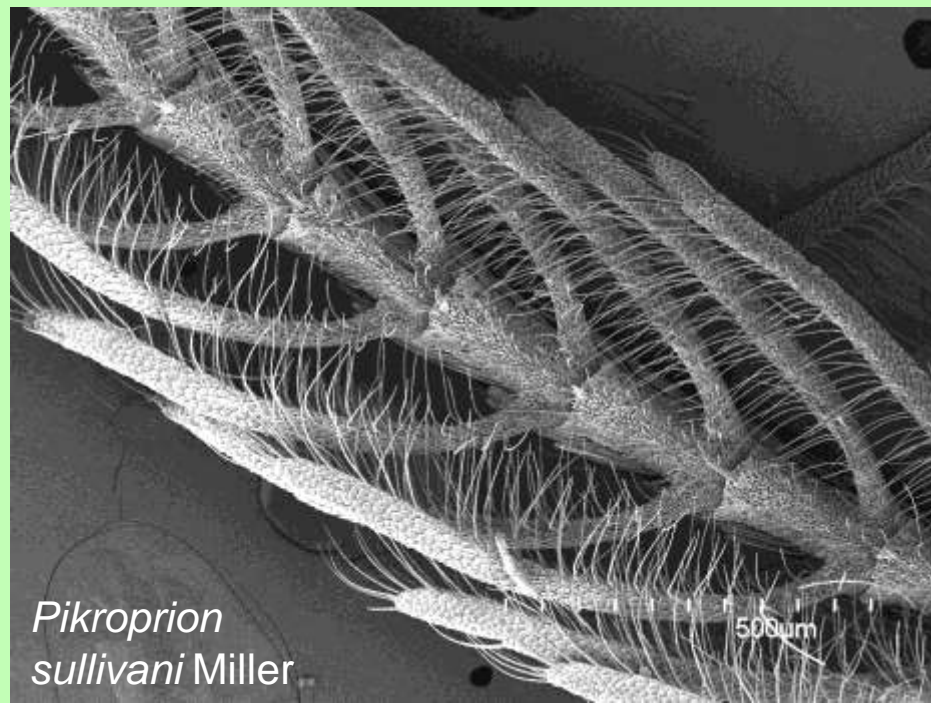


Autochton longipennis
male (Bahia, Brazil)

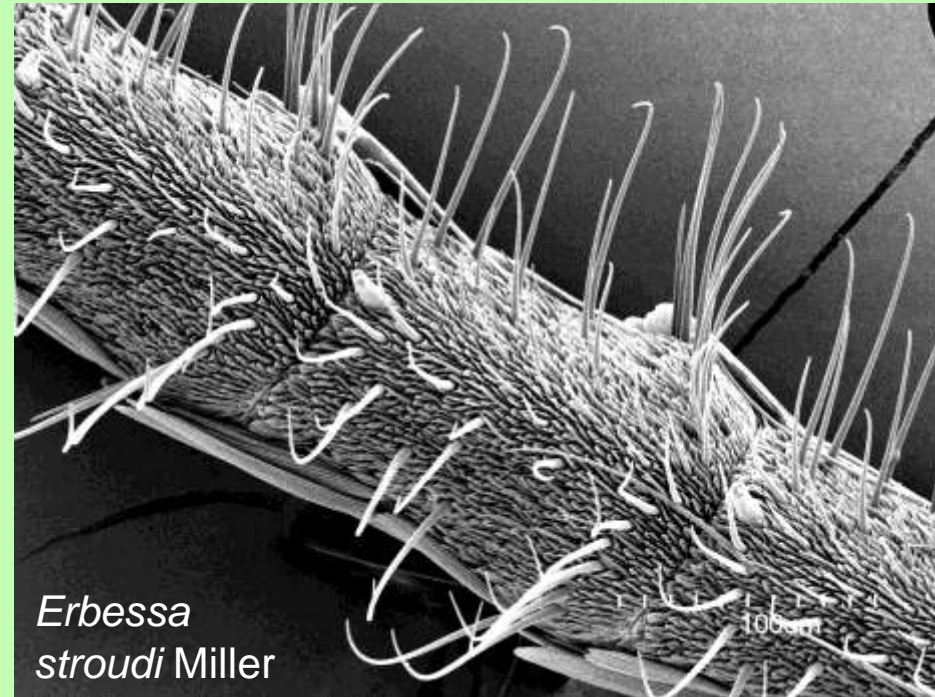
Papilio glaucus male
(North Carolina)



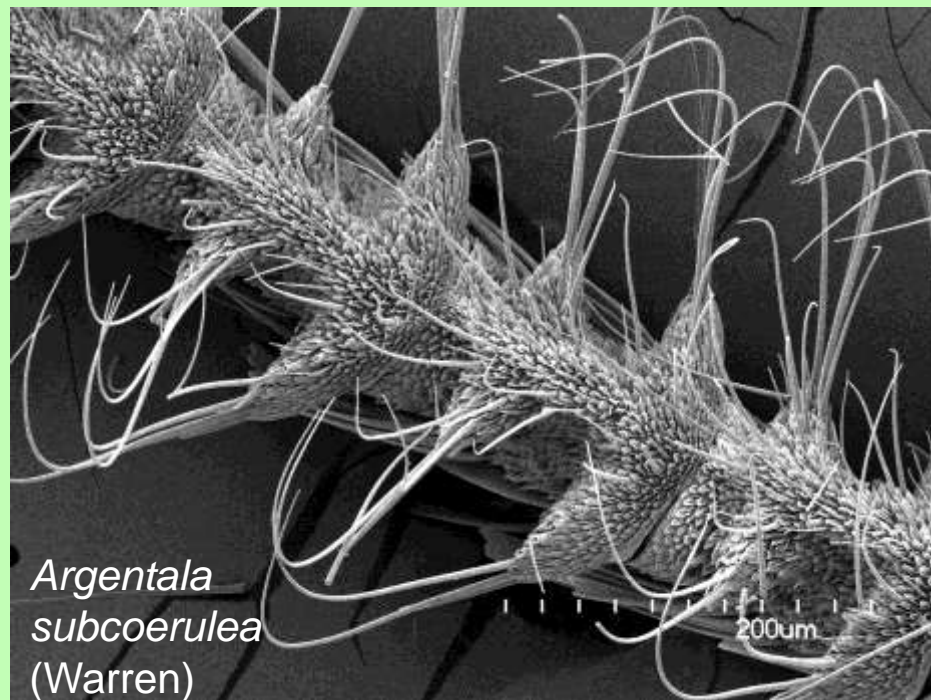
Stichelia sagaris female (Bahia, Brazil)



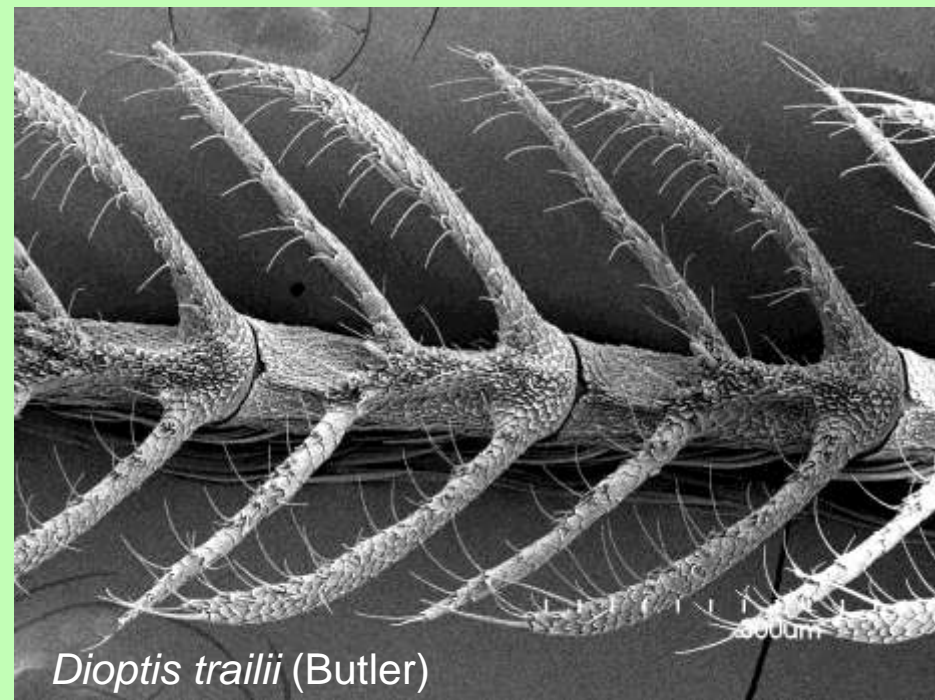
*Pikroprion
sullivanii* Miller



*Erbessa
stroudi* Miller



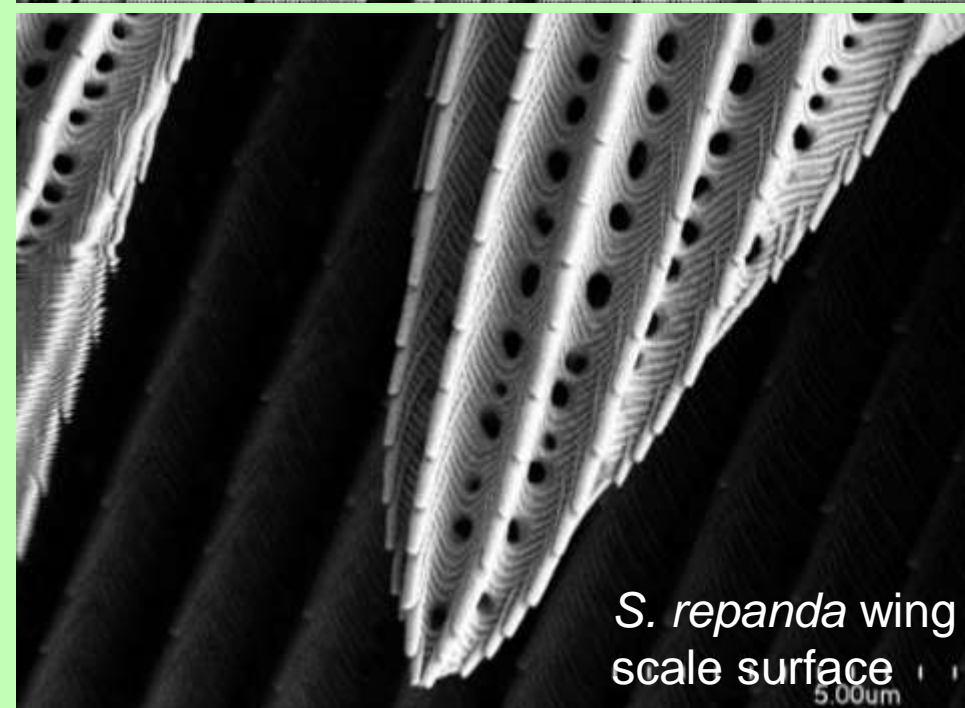
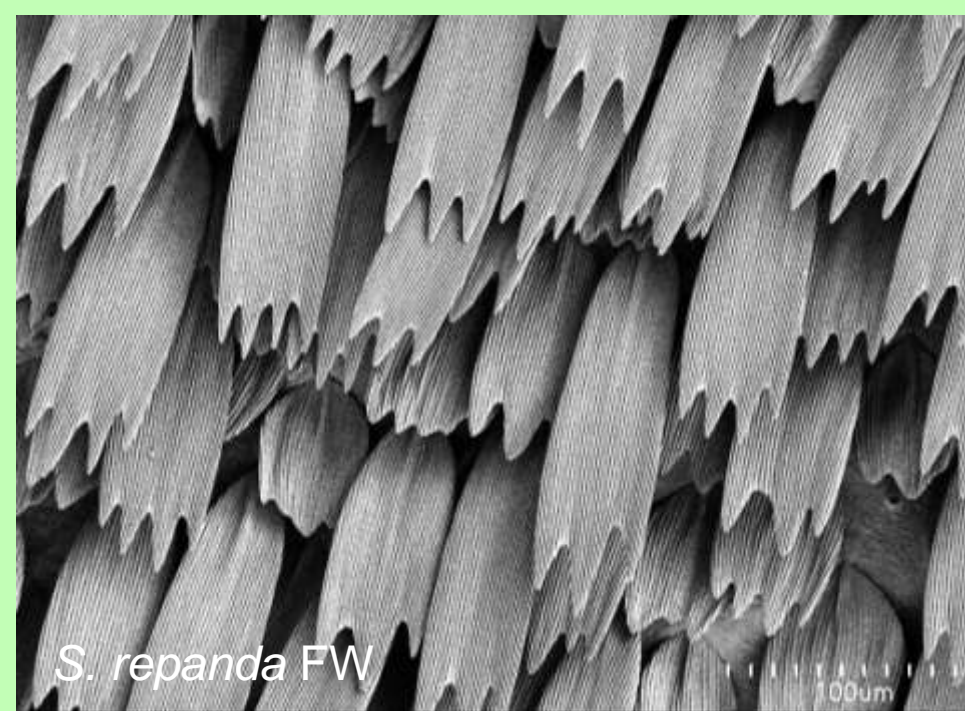
*Argentala
subcoerulea*
(Warren)



Dioptis trailii (Butler)

LEPIDOPTERA (from ancient Greek):
Lepido = scale, *ptera* = wing; “the scaly-winged insects”.

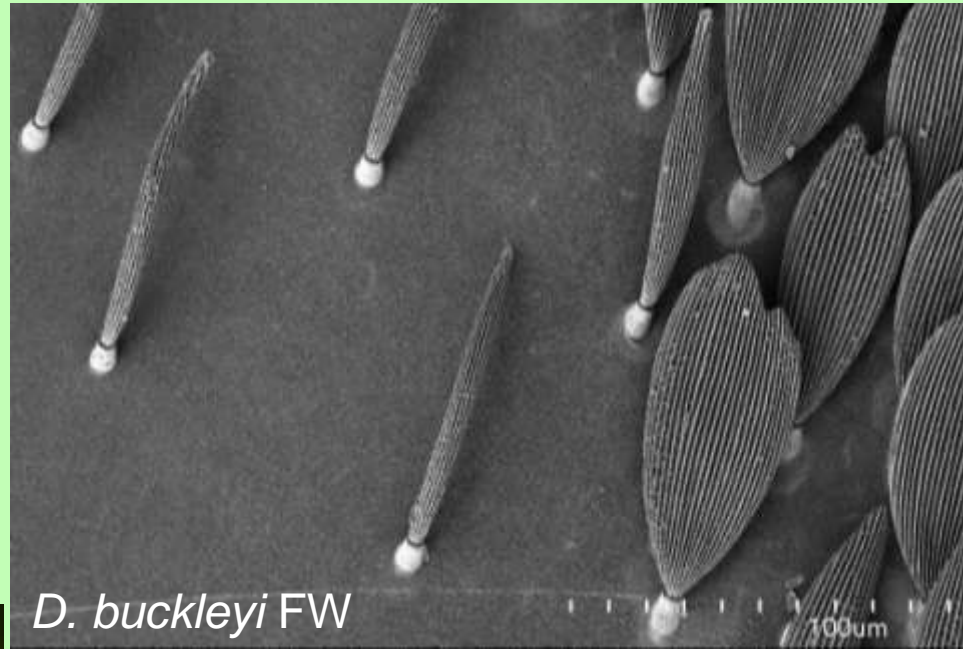
- The entire body is covered with scales; these vary in shape and function.



Hyaline wings in Ctenuchini (Erebidae: Arctiinae); wasp mimics.

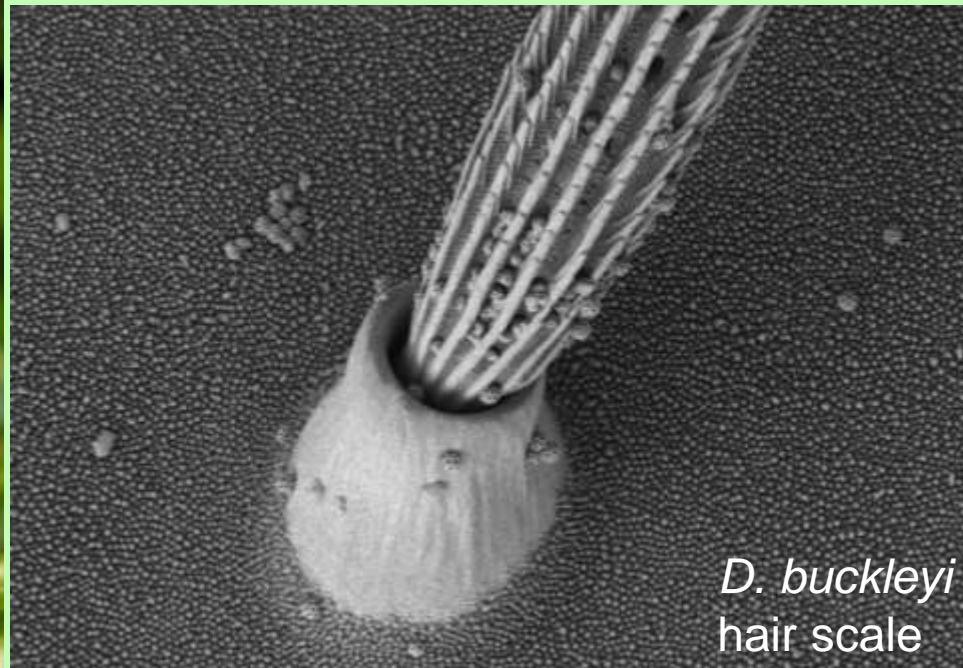


Dasysphinx buckleyi (E Ecuador)

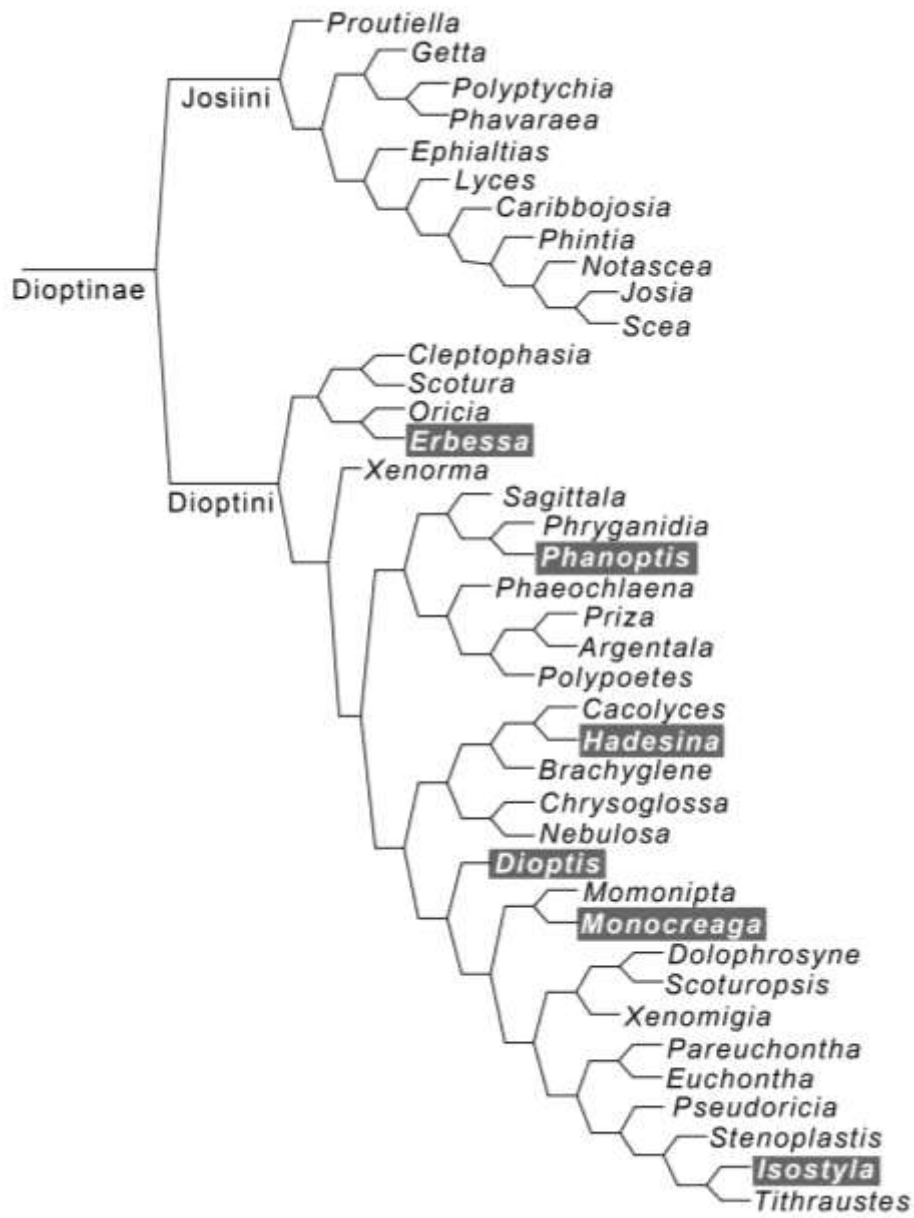


D. buckleyi FW

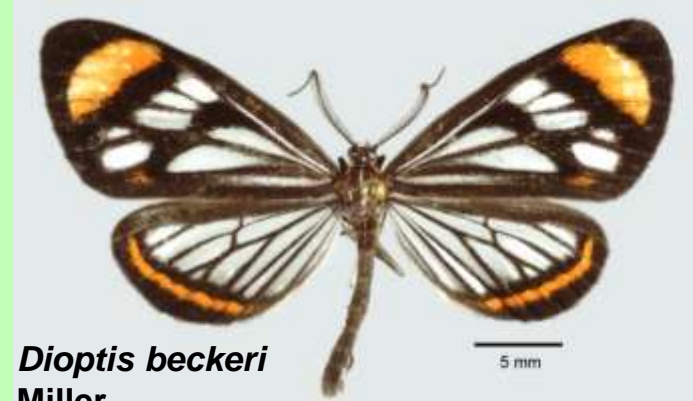
Pseudosphex sp.
(SE Brazil)



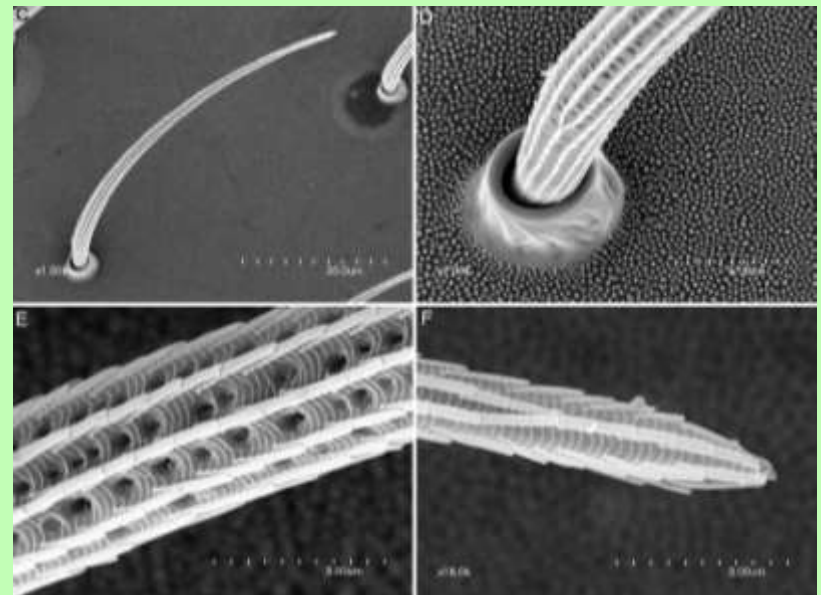
D. buckleyi
hair scale



Phanoptis vitrina Felder

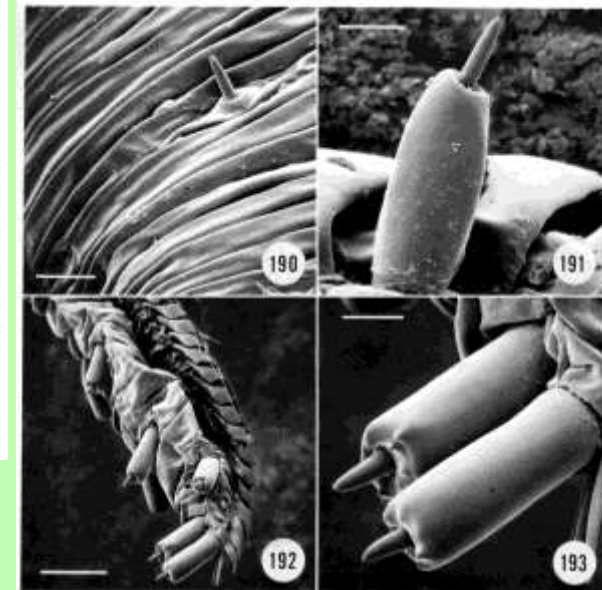
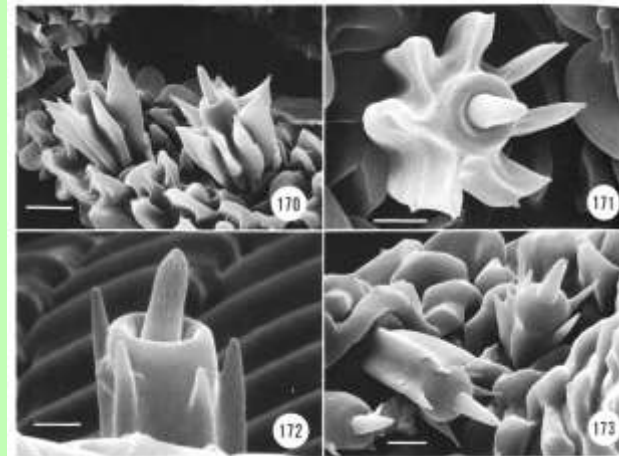
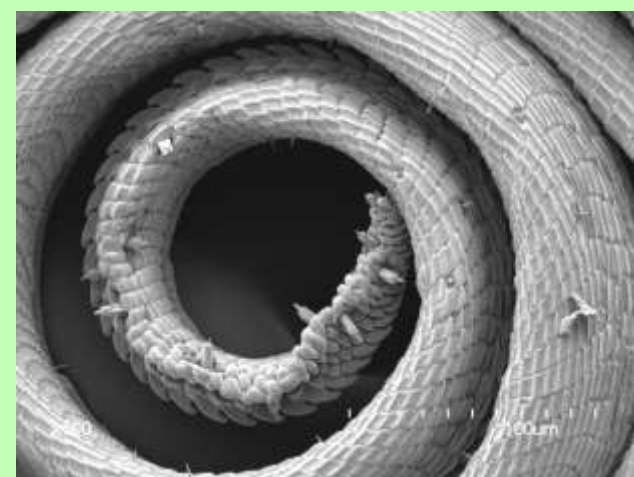
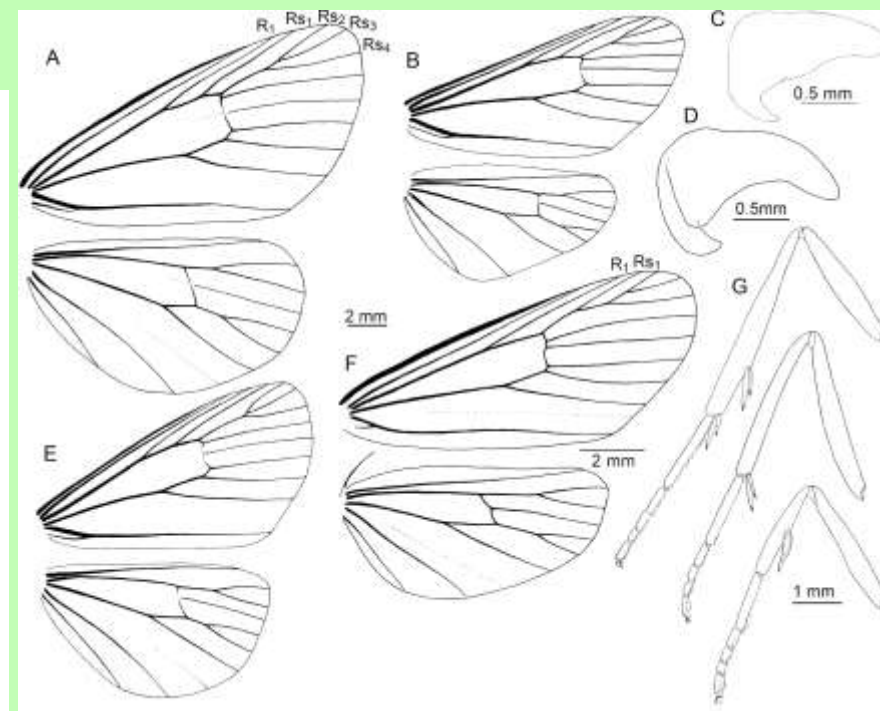
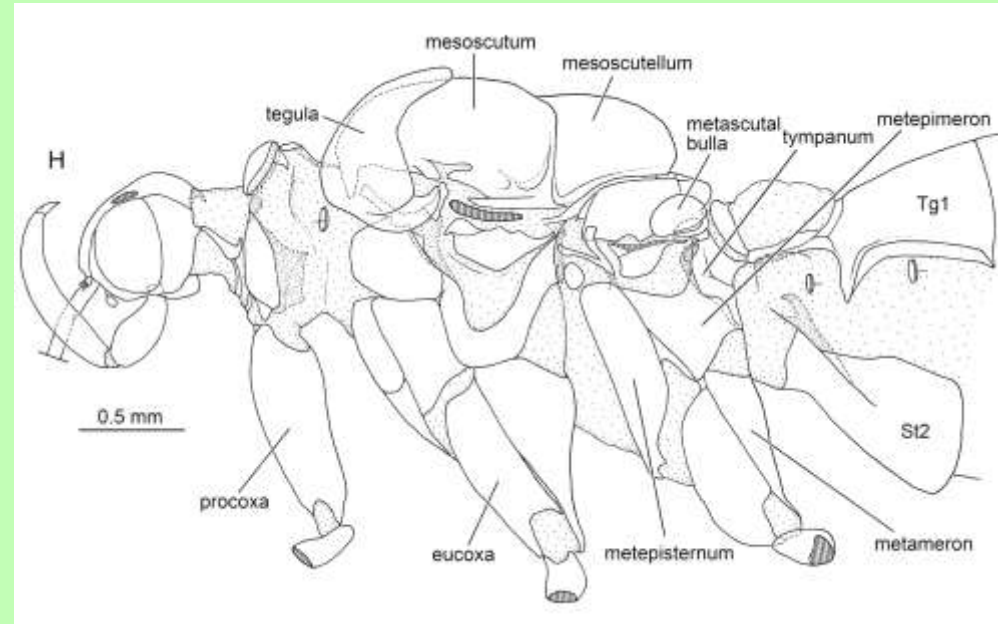


Diopsis beckeri Miller



Hyaline wings have evolved at least 5 times in the Dioptinae.

Adult skeletal morphology (scales removed).



Sensilla styloconica on the distal portion of the proboscis; receptive to sugars and amino acids.



Smryna blomfildia (Nymphalidae)



S. blomfildia drinking sweat (W Ecuador)



S. blomfildia on guava fruit



S. blomfildia
proboscis sensilla

50.0um

Butterflies and moths feeding on *Eupatorium* flowers in western Ecuador



Adelpha cytherea
(Nymphalidae)



Calycopis origo
(Lycaenidae)



Rekoa meton
(Lycaenidae)



Archonias tereas
(Pieridae)



Diptilon chrysocraspis
(Arctiinae: Ctenuchini)



Saurita cassandra
(Arctiinae: Ctenuchini)

“Puddling” behavior in butterflies and moths – the quest for sodium

“mixed flock”
NE Ecuador

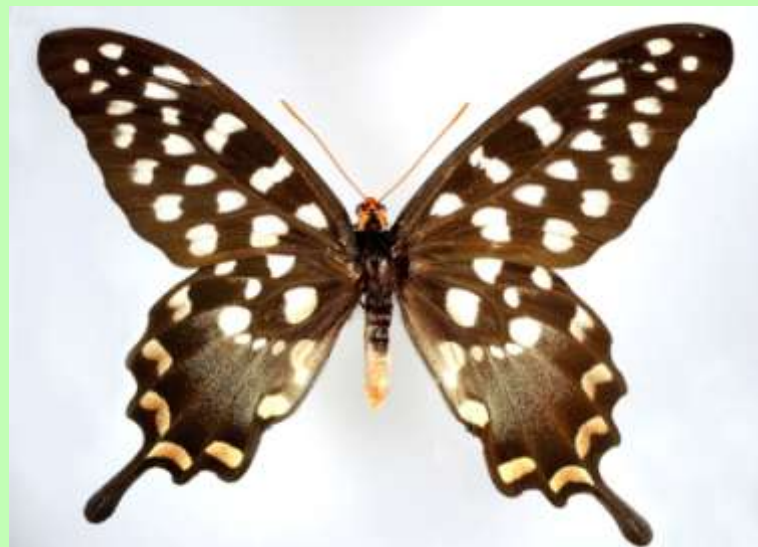
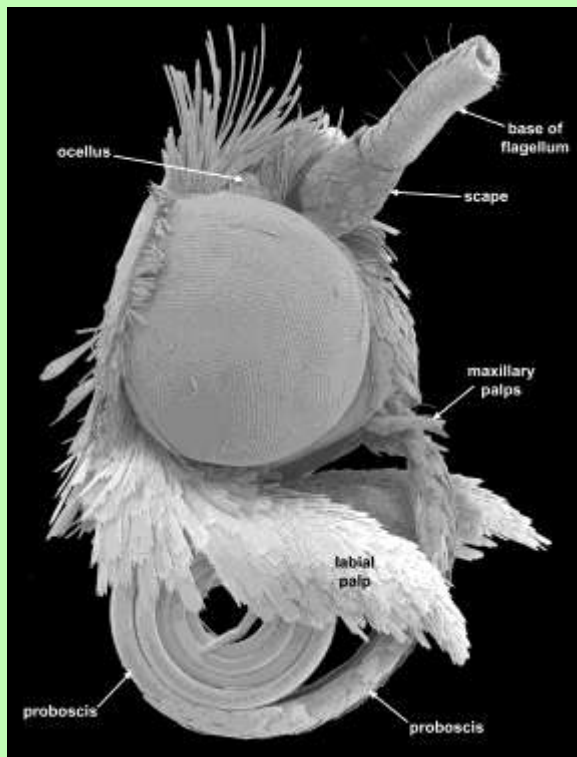


Phaeochlaena lampra
(Notodontidae) Brazil

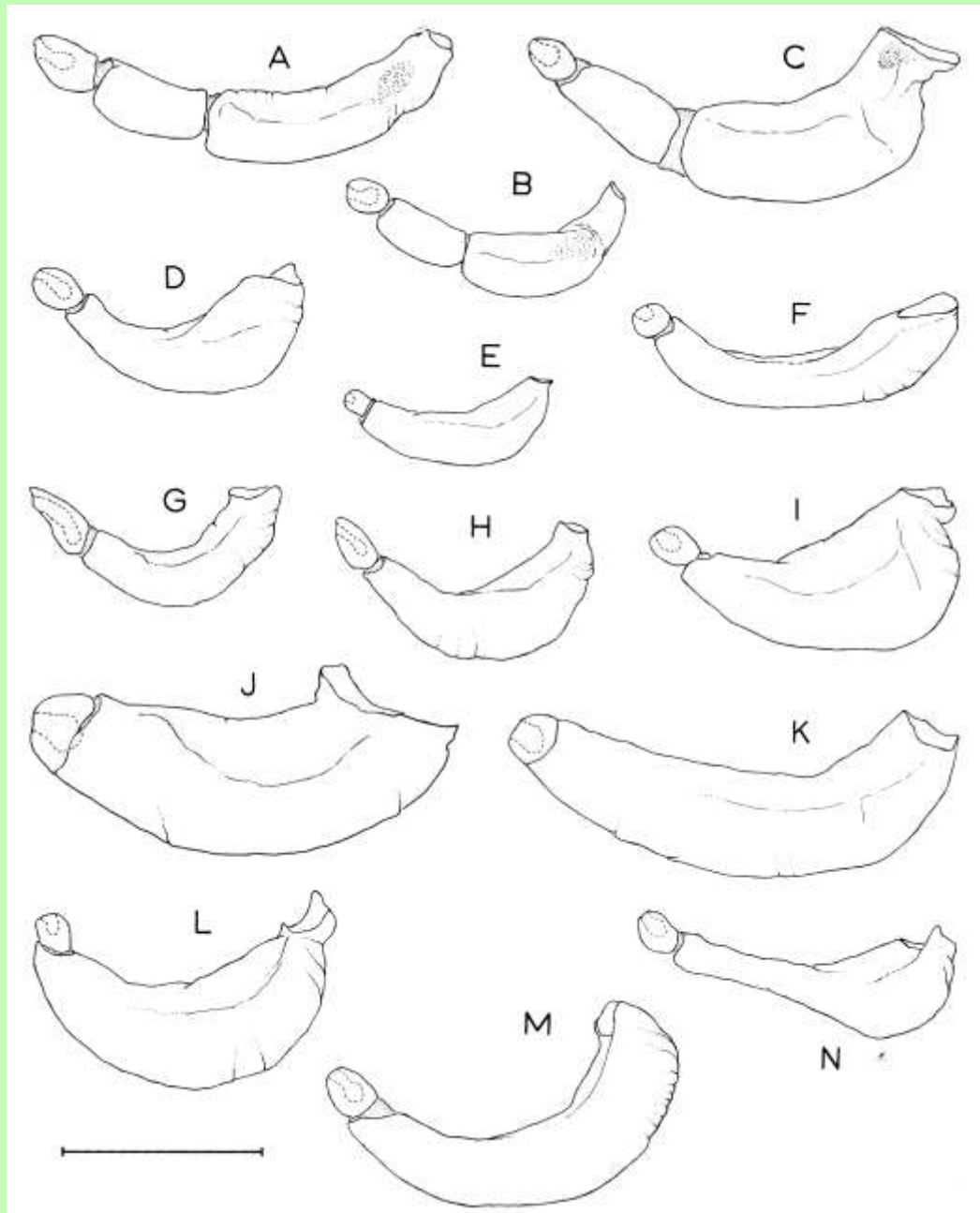
Altinote sodalis (Nymphalidae)
on snake roadkill, SE Peru



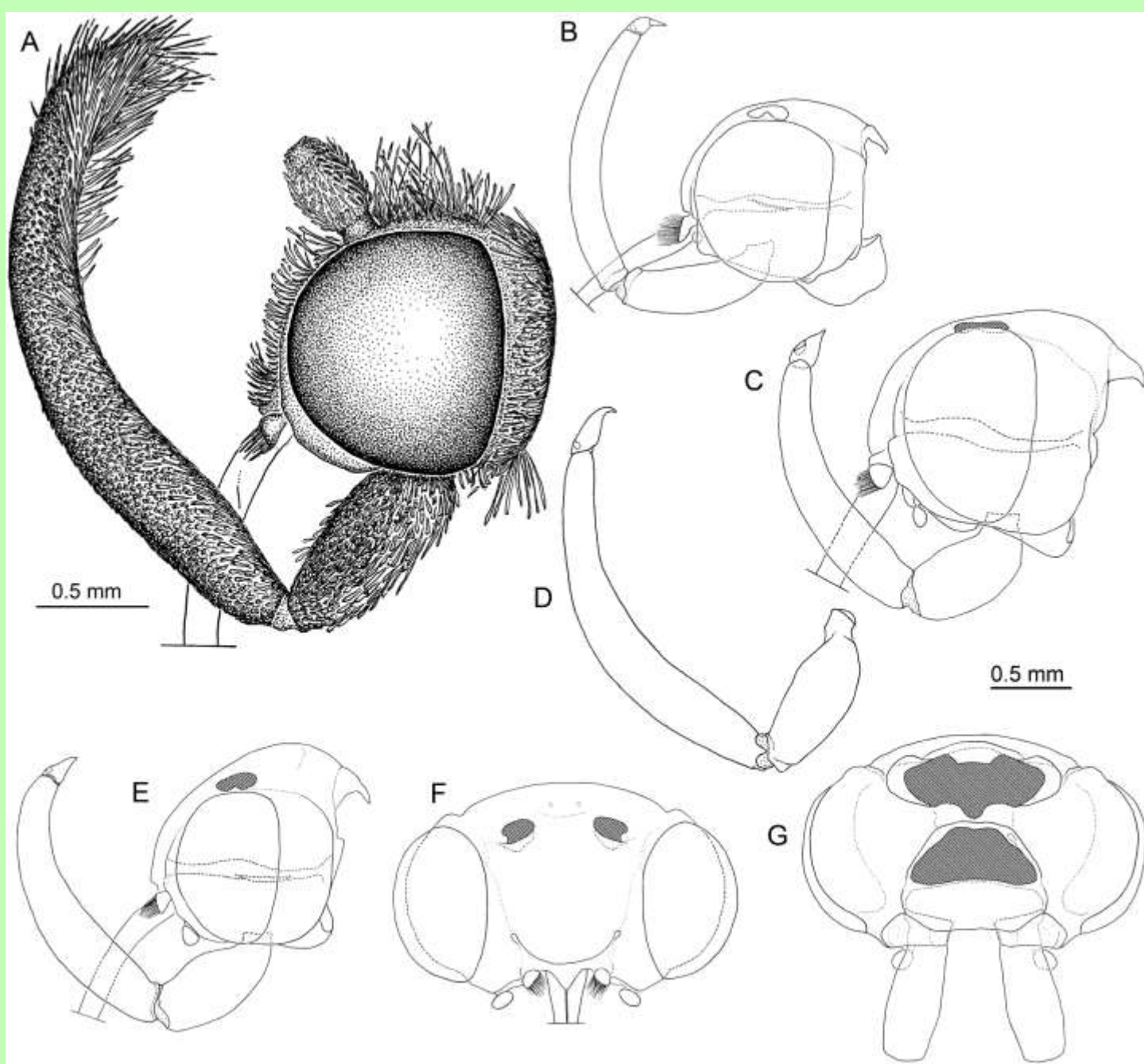
Satyrinae on agouti poop, NE Ecuador



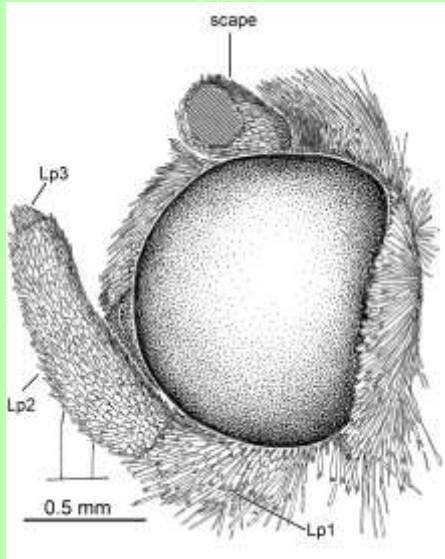
Pharmacophagus antenor
(Madagascar)



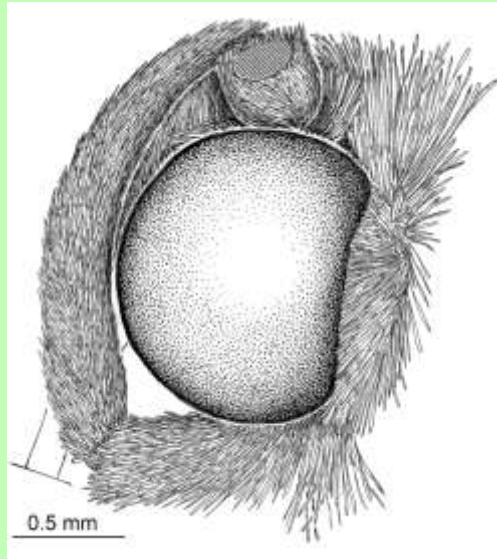
Labial palpi of the Troidini



Heads of *Erbessa* species



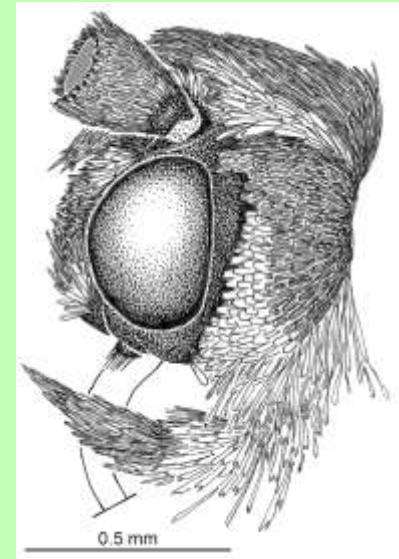
***Cleptophasia
scissa* (Warren)**



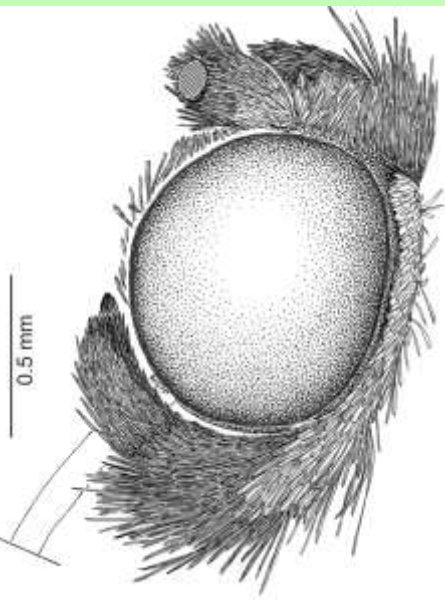
***Oricia truncata*
Walker**



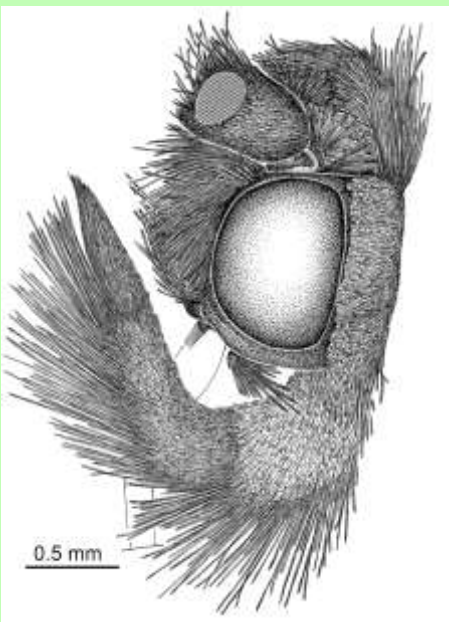
***Euchontha
carboniptera* Miller**



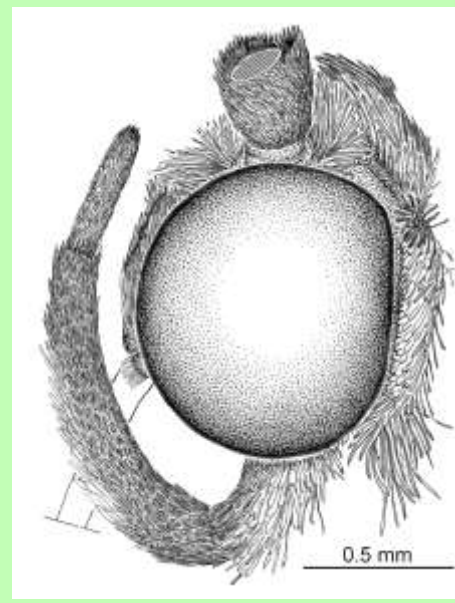
***Dolophrosyne
coras* (Druce)**



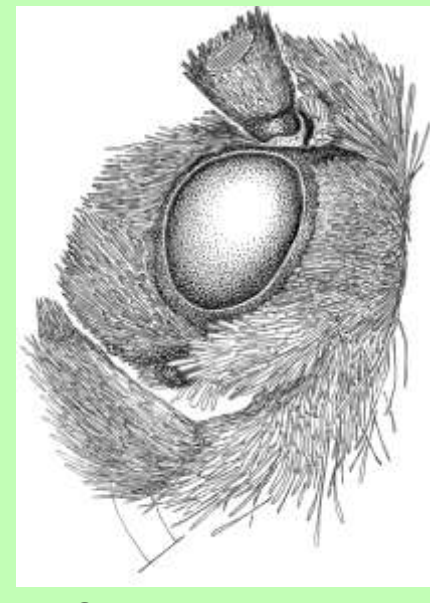
***Nebulosa
huacamayensis* Miller**



***Getta unicolor*
(Hering)**



***Tithraustes
lambertae* Miller**

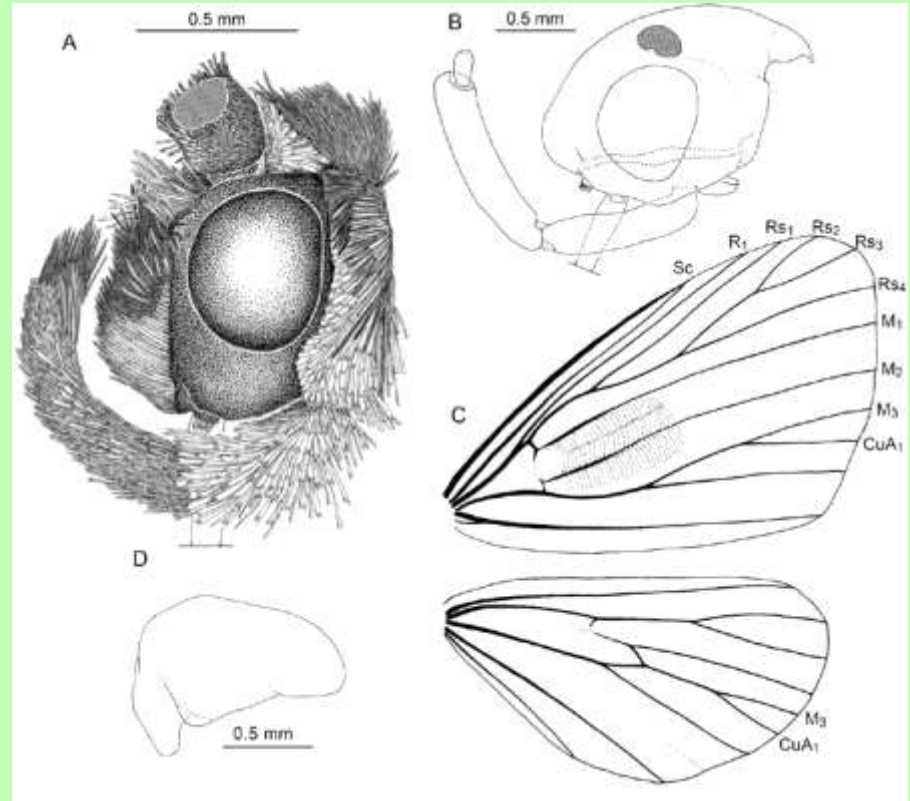


***Scoturopsis
franclemonti* Miller**

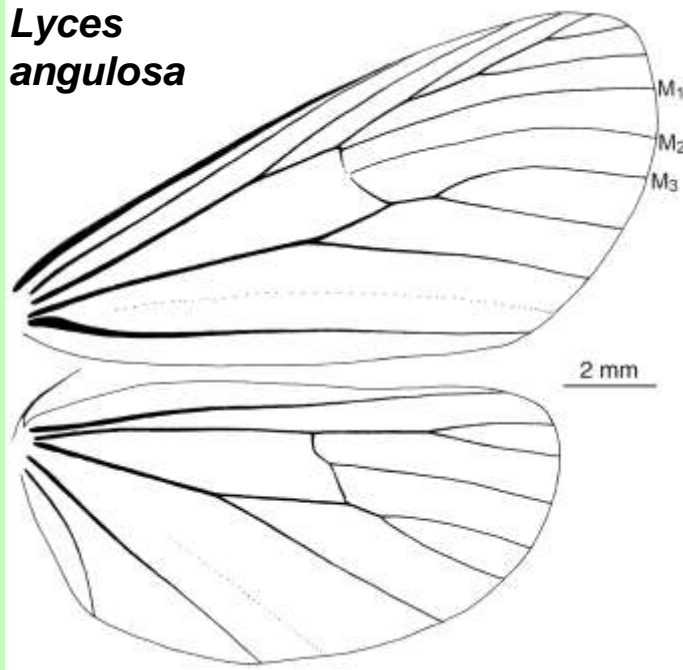
Río Papuncu
Napo, Ecuador
(900 m)



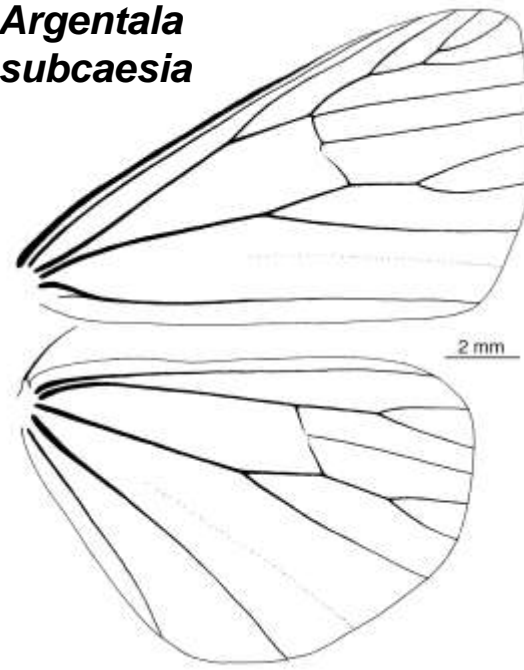
Euchontha frigida (Walker)



***Lyces
angulosa***



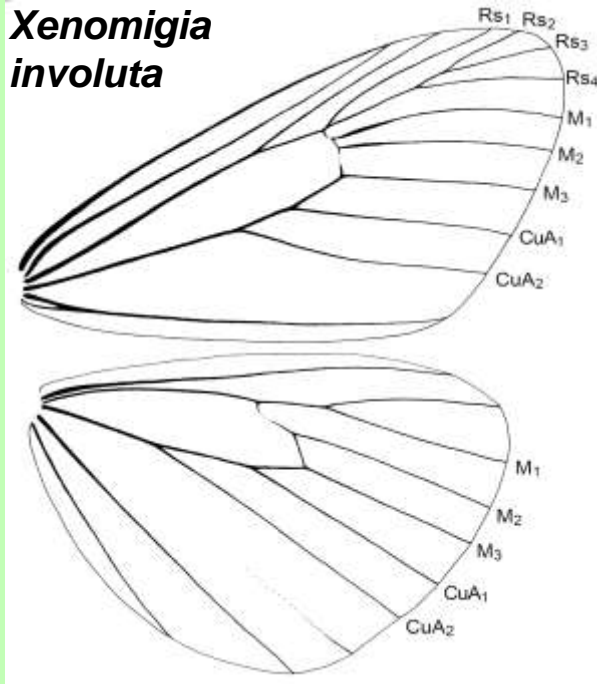
***Argentalia
subcaesia***



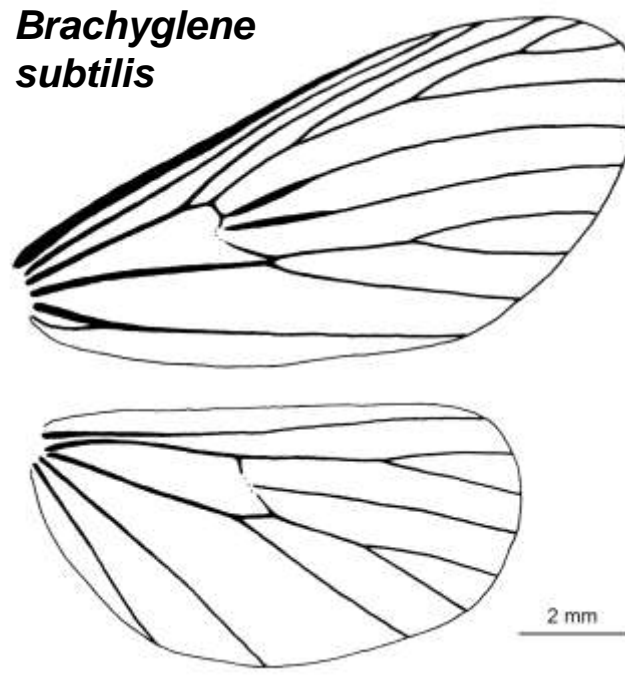
- standardized system of nomenclature for Lepidoptera wing veins in use since 1843.

- characters from wing venation used in early Dioprinae classifications.

***Xenomigia
involuta***



***Brachyglene
subtilis***



- 180 dioptrine species in 22 genera possess a male forewing stridulatory organ.

Major lineages in the superfamily Noctuoidea (70,000 described spp):



Oenosandridae – 8 spp.
(Australia & Tasmania)



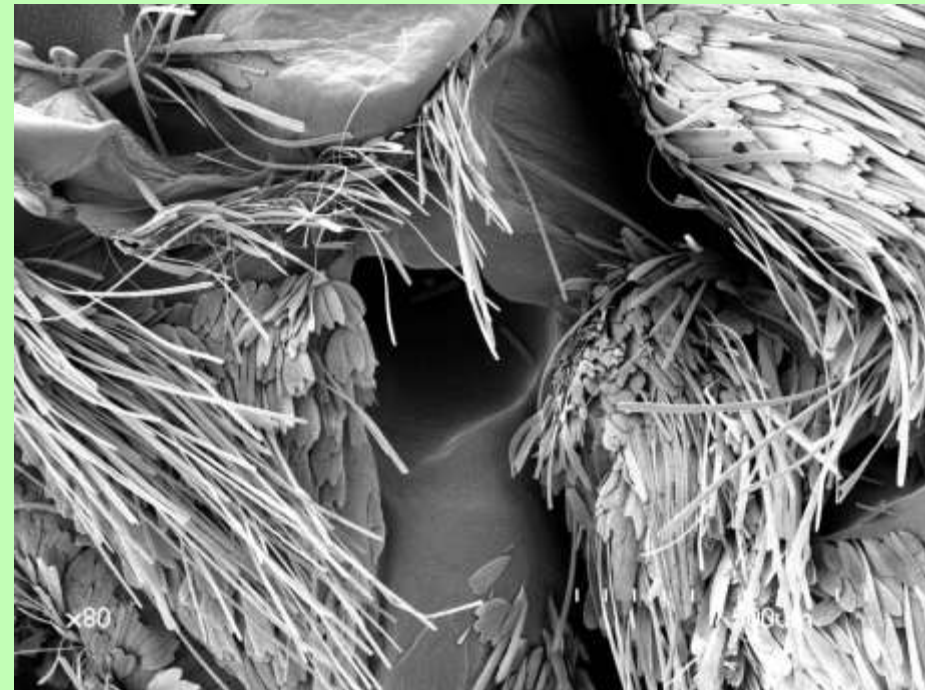
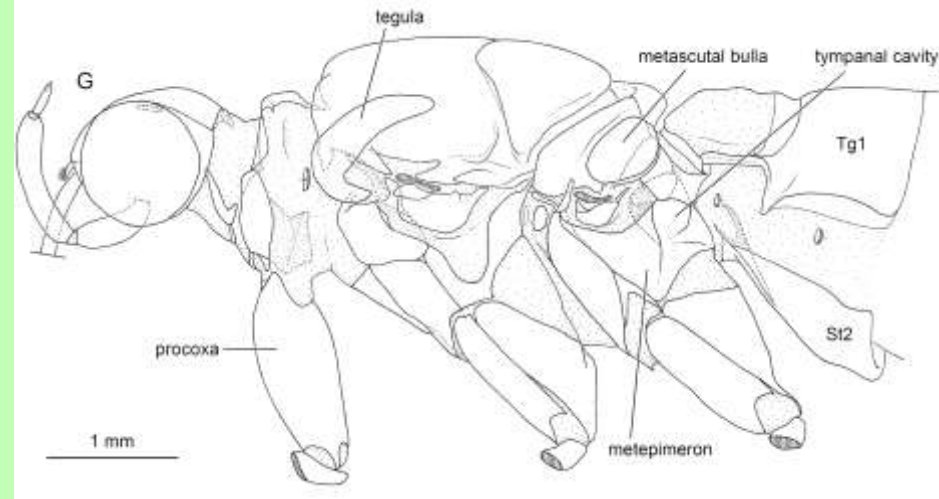
Notodontidae – 3,800 spp.
(incl. Dioprinae)



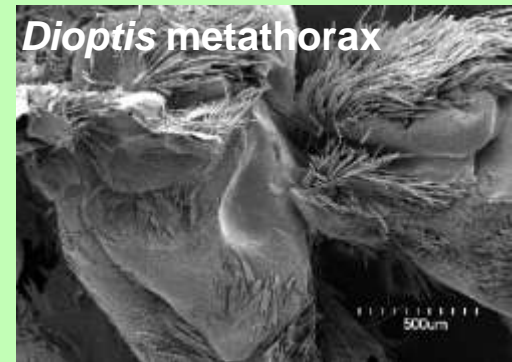
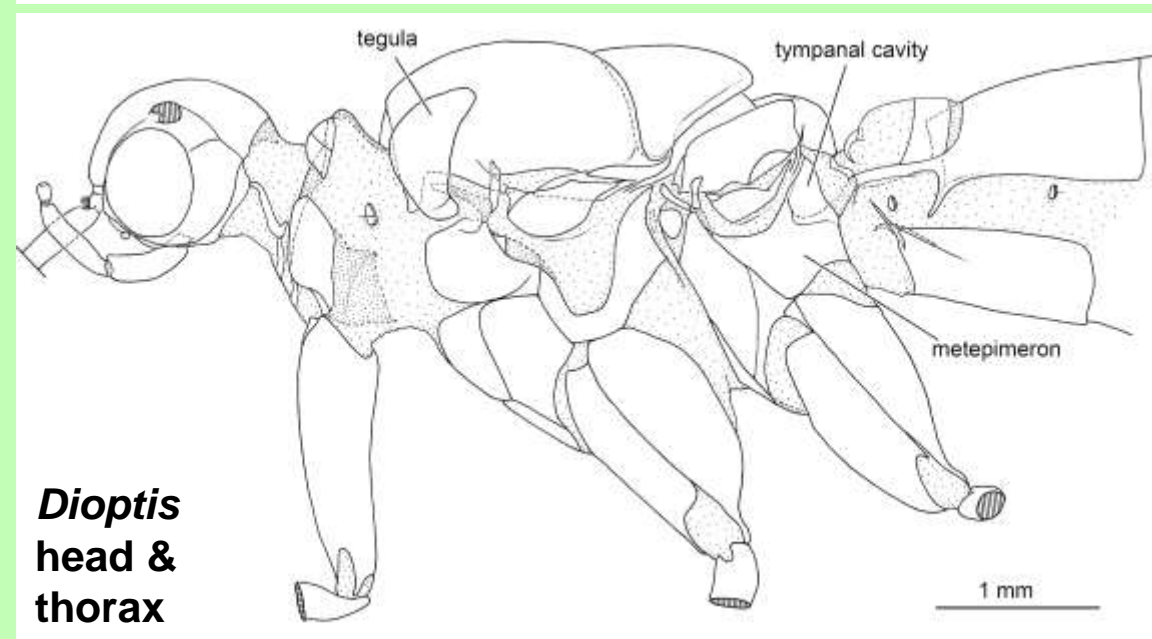
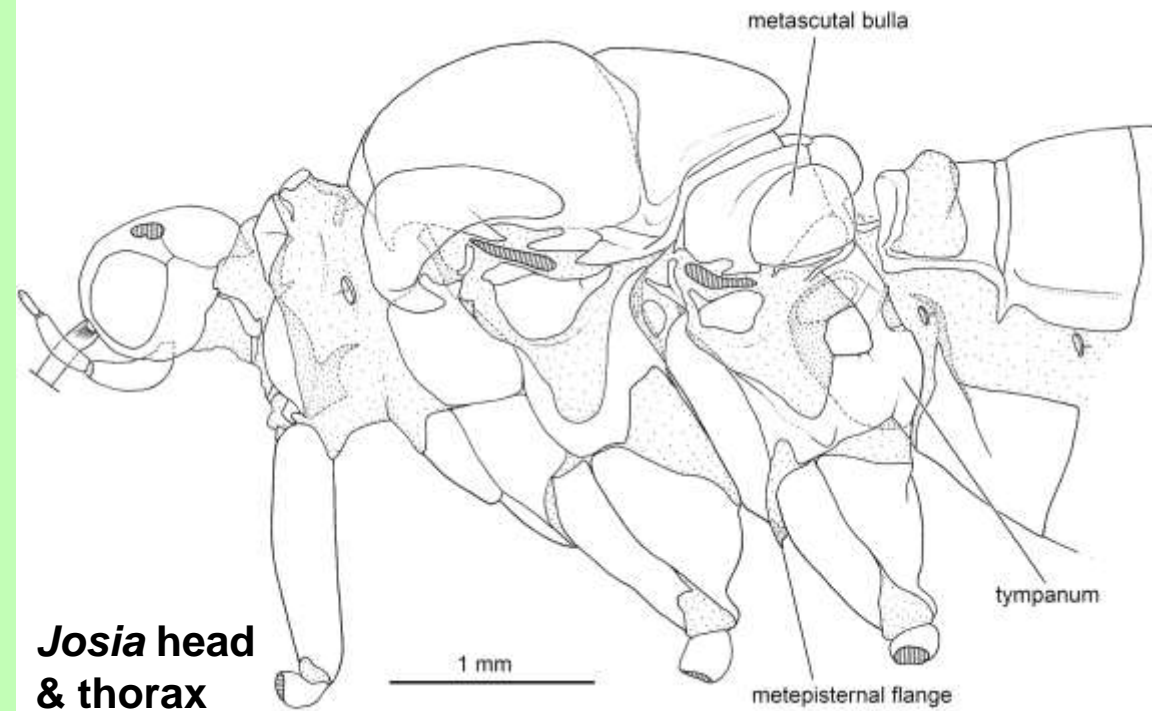
Erebidae – 24,500 spp.
(incl. Arctiinae)



Noctuidae – 12,000 spp.

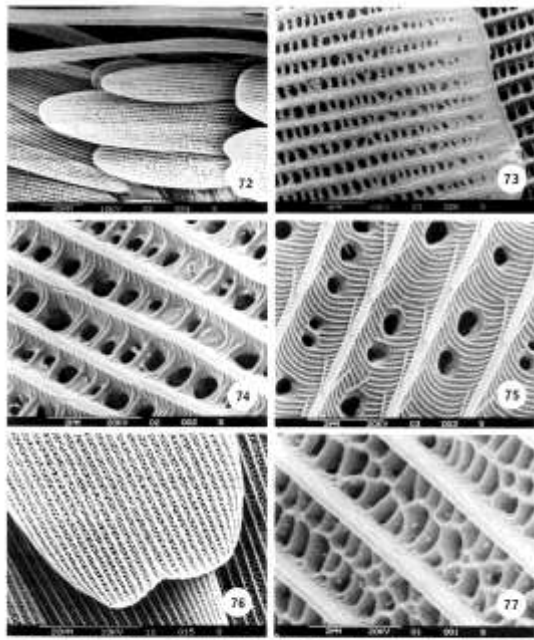
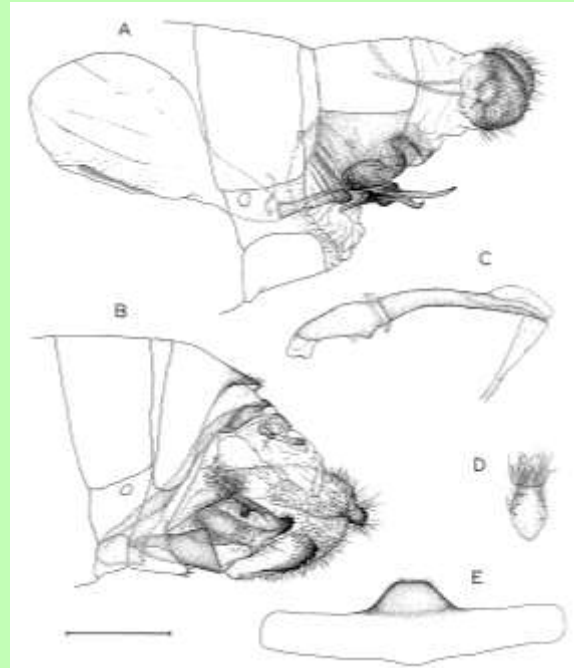
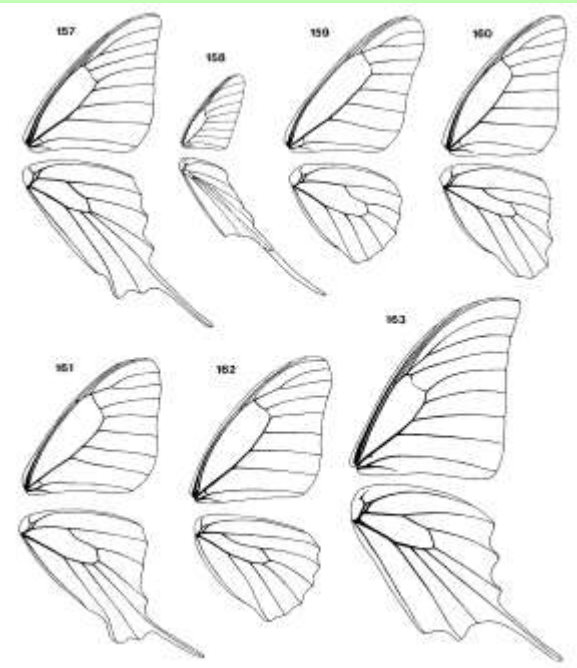


- Noctuoidea defined by presence of a metathoracic tympanum; thought to have evolved for detecting bat cries.

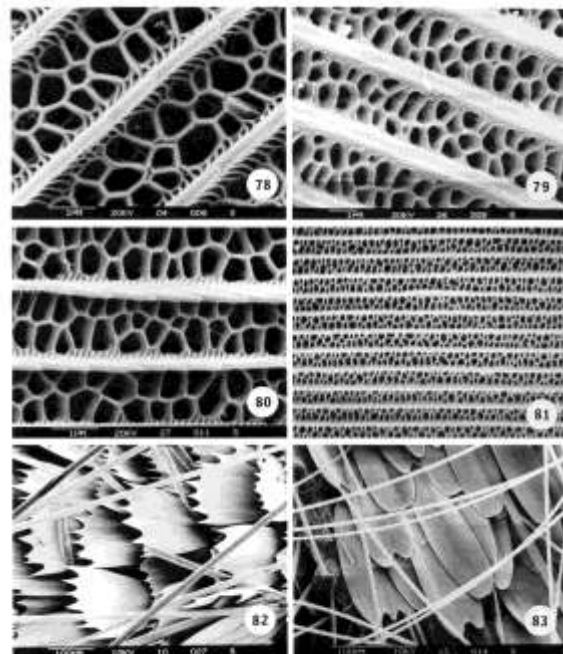




Graphium weiskei (New Guinea)



Figs. 72-77 [Character 23]. Male hind wing scales. 72, *Dioretopha asaphes* (Pieridae), hind wing margin; 73, *Parnas apas* (Pieridae), close-up of scale from hind wing margin; 74, *Graphium weiskei*, close-up of typical hind wing scale; 75, *Graphium weiskei*, close-up of typical hind wing scale; 76, *Papilio machaon*, scales from hind wing margin; 77, *Merisiphus pectus*, close-up of typical hind wing scale.



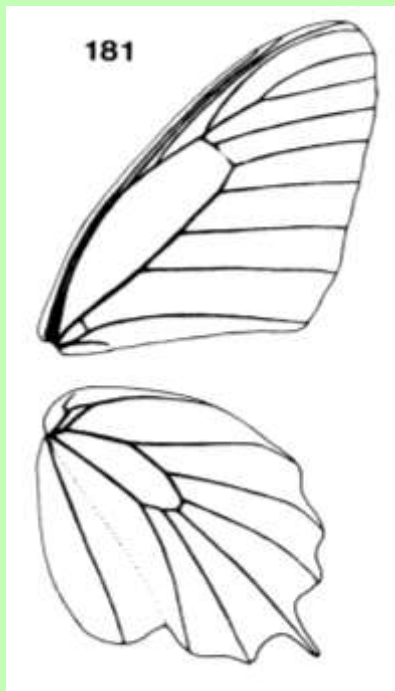
Figs. 78-81 [Character 23]. Typical male hind wing scales. 78, *Pachlopterus (Louraea) neptunus*; 79, *Pachlopterus (Pachlopterus) heister*; 80, *Parnas (Graphium) weiskei*; 81, *Graphium weiskei*. Figs. 82, 83 [Character 18]. Male hind wing margin. 82, *Papilio machaon*; 83, *Papilio machaon*.

Miller, J.S. 1987. Phylogenetic studies in the Papilioninae (Lepidoptera: Papilionidae). AMNH Bulletin 186: 365-512.

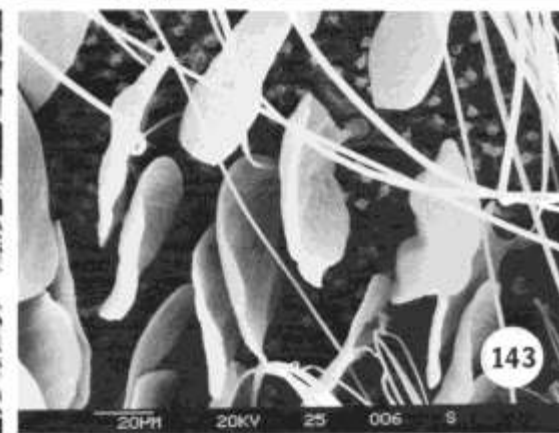
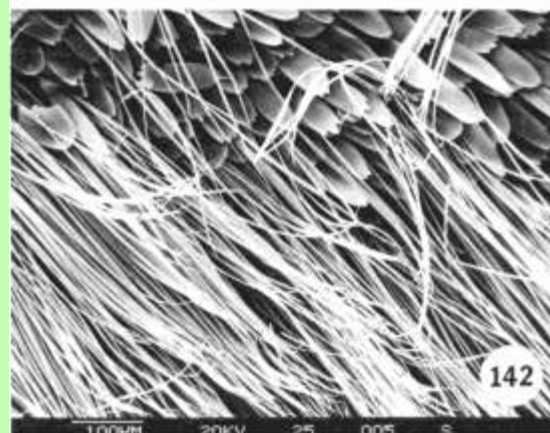
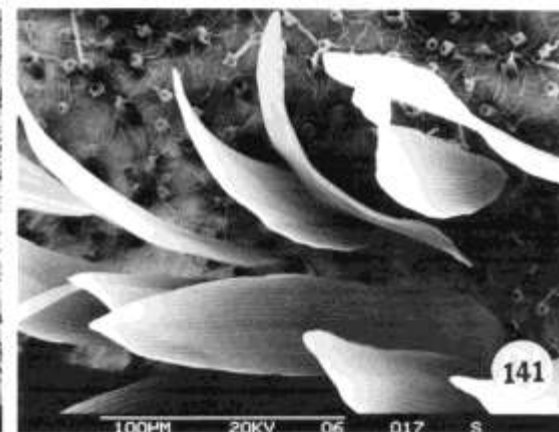
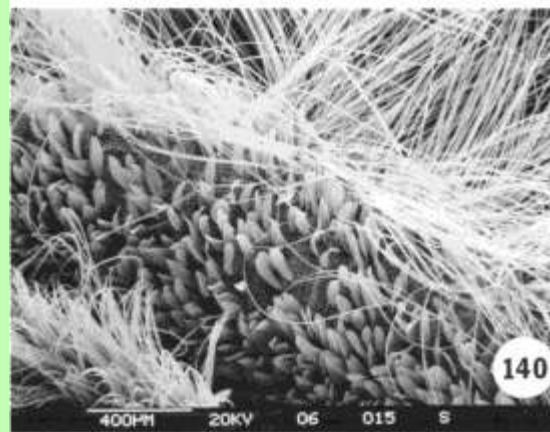
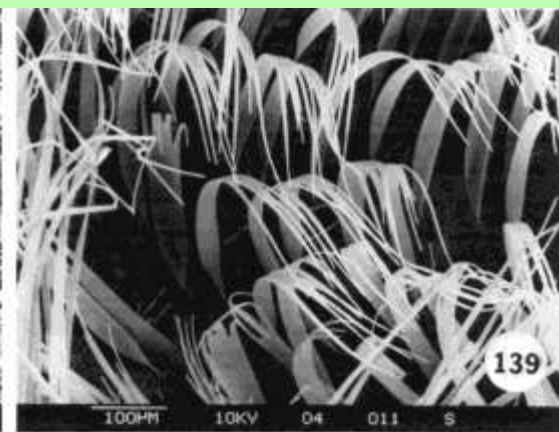
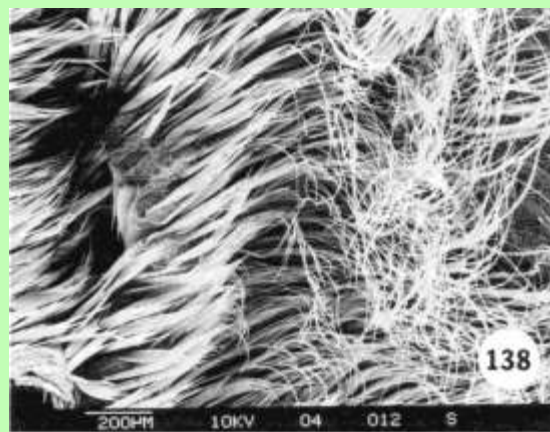
- 50 swallowtail exemplars.
- 170 characters from adult morphology.
- first numerical cladistic analyses for the family.



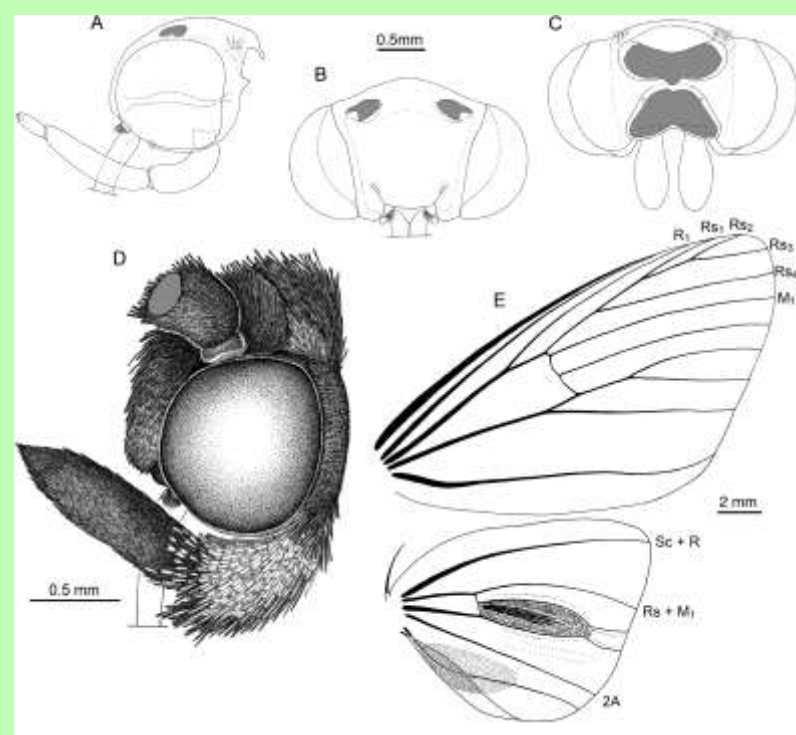
***Pachliopta neptunus* male
(Palawan)**



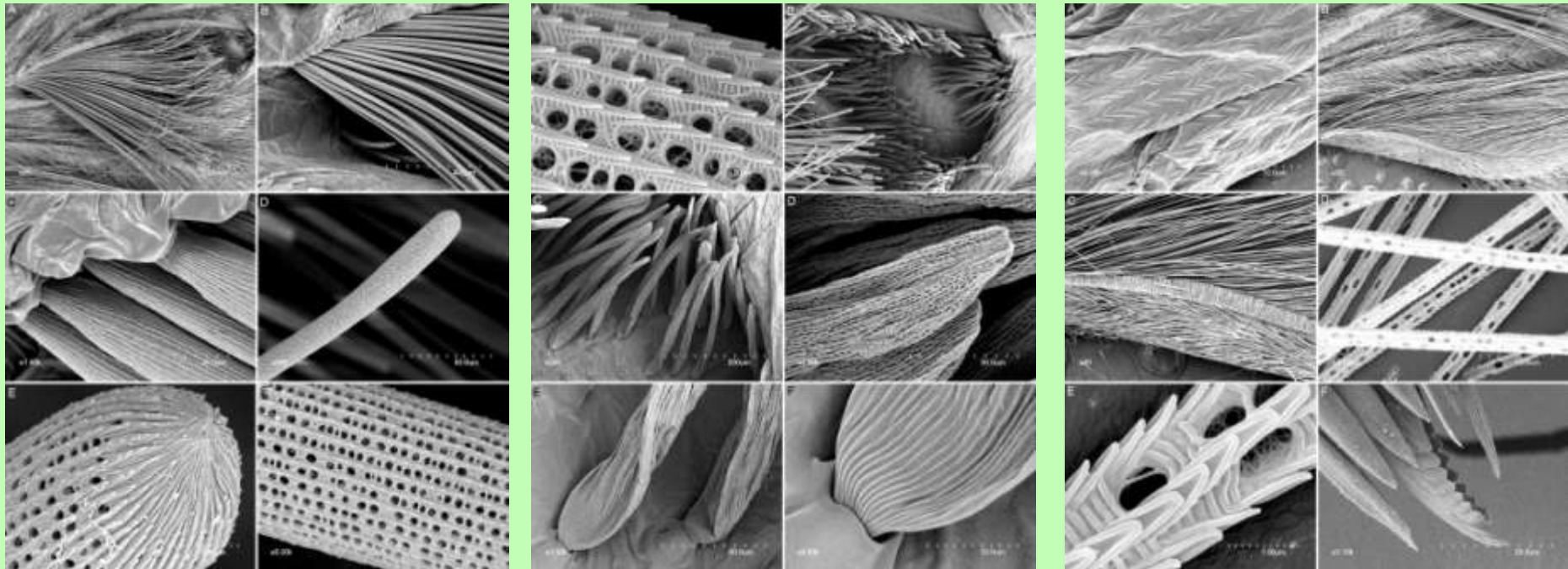
***Parides
photinus* male**



**Troidine androconia in HW anal margin
(from Miller, 1987)**



HW androconia of *Polyptychia hermieri* Miller





1-4 DAMAS CLAVUS.
5-8 ORYS CYNISCA.
9-12 IKICOLOR.
13-16 THRACIDES PHIDON.

17-20 THRACIDES DECEPTUS.
21-24 LUDA.
25-28 MOLTON.
29-32 SERON.

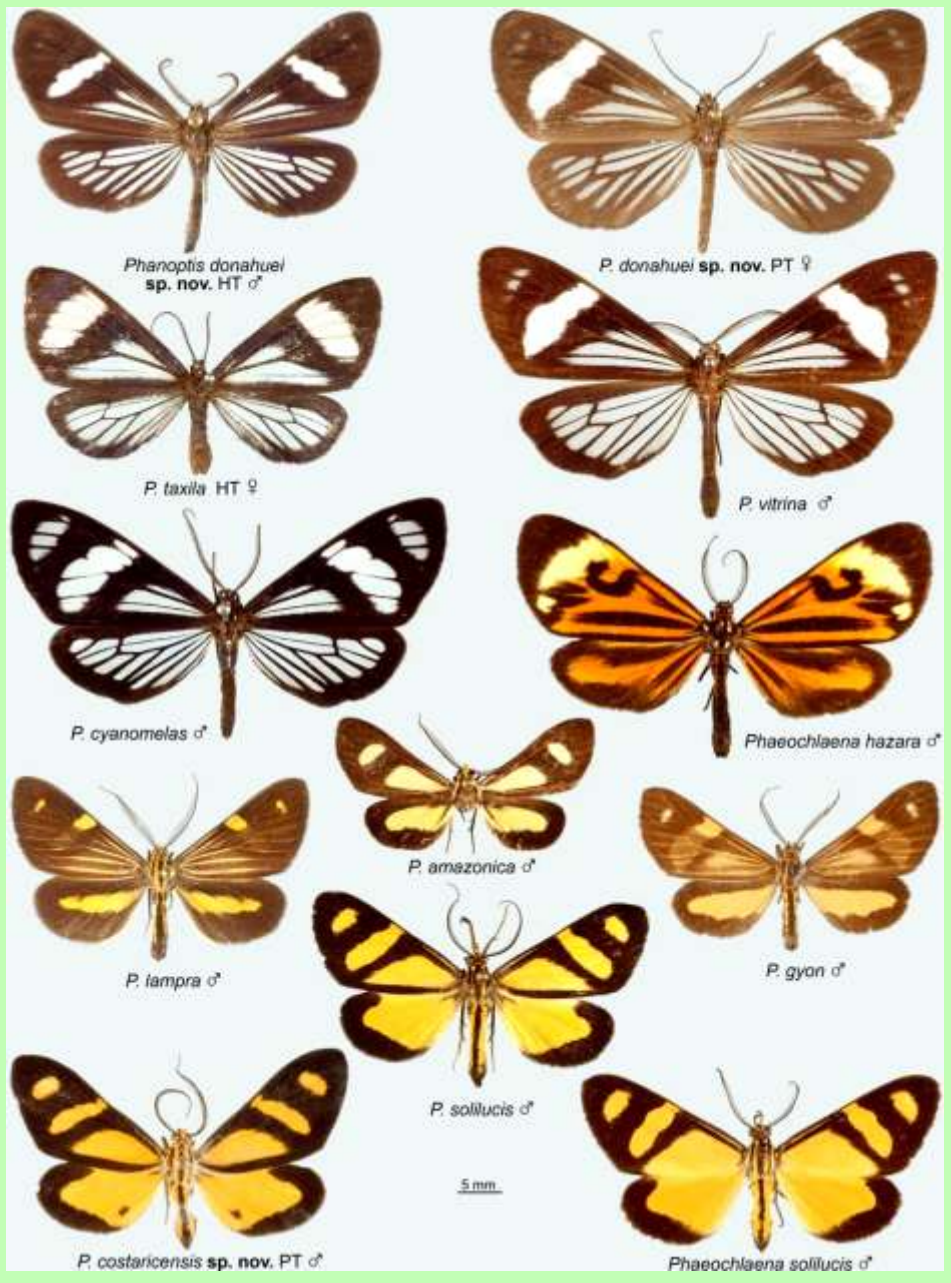
33-36 THRACIDES HENRICUS.
37-40 KRUMA.
41-44 AURIFER.
45-48 POLLES.

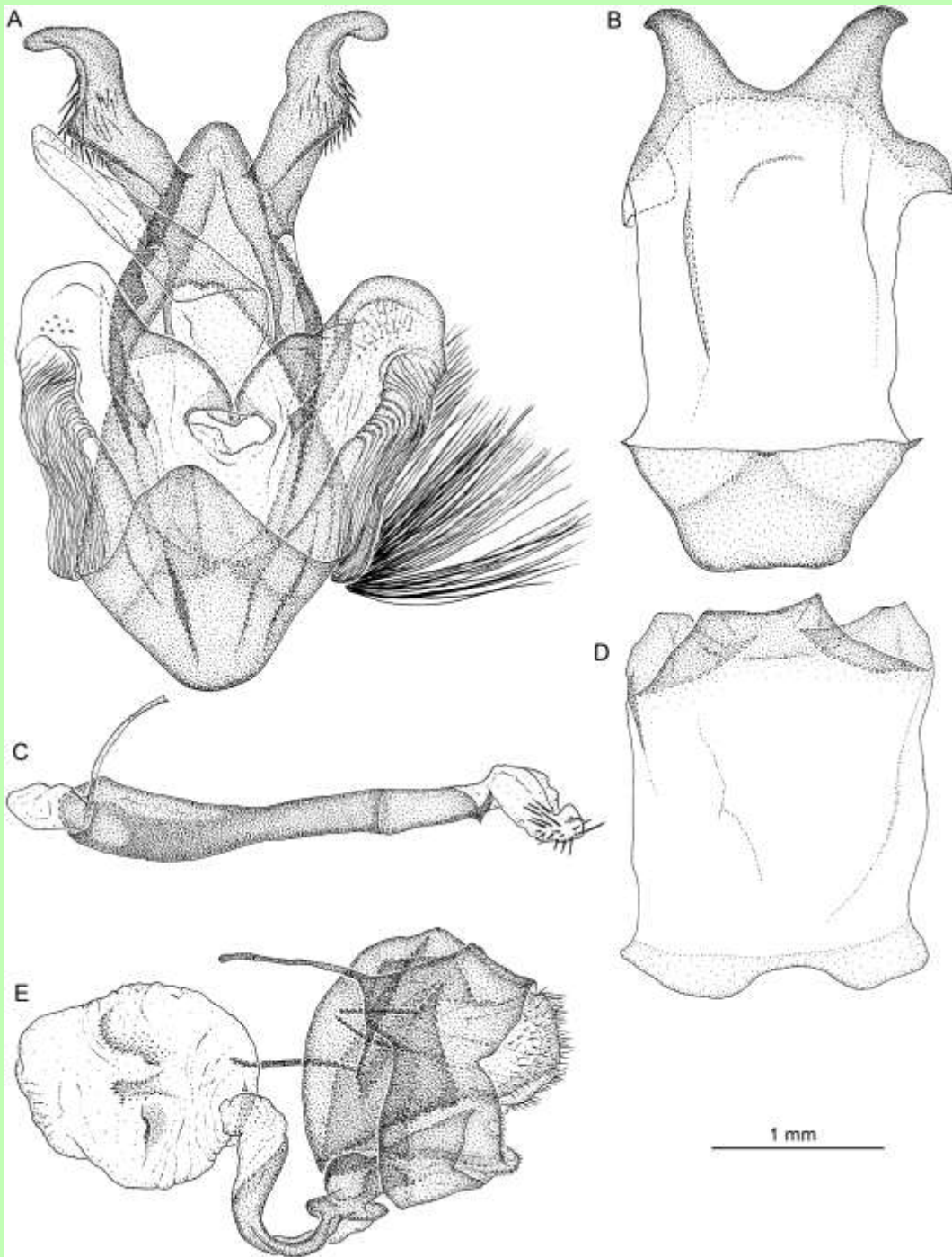
- characters from genitalia used in Lepidoptera systematics for over 100 years.

- not utilized in previous works on the Diopinae.

Skipper butterflies, their male genitalia and wings.

**From: Godman & Salvin (1879-1901)
Biologia Centrali-Americana.**

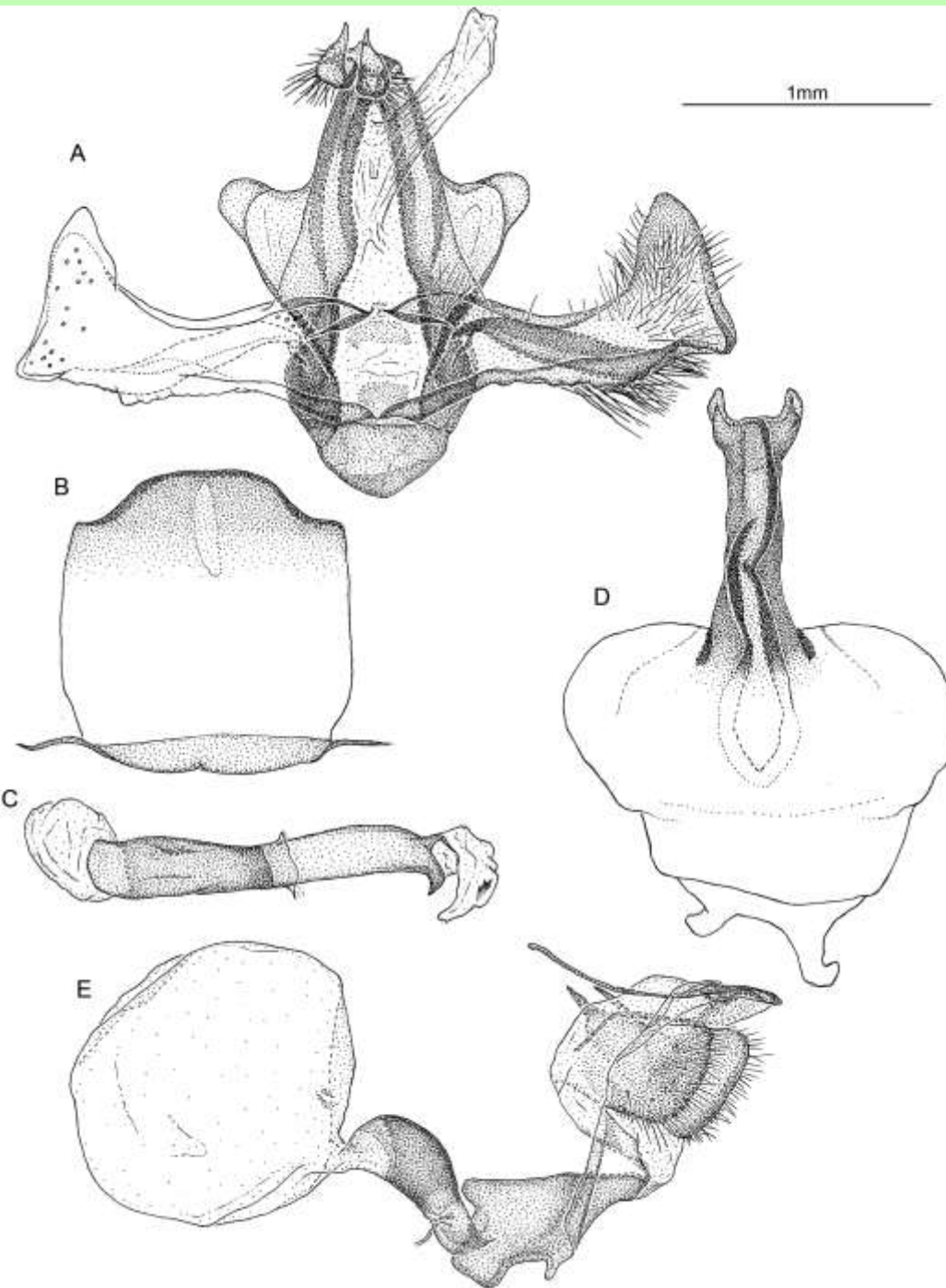




Polypoetes wagneri Miller, 2009



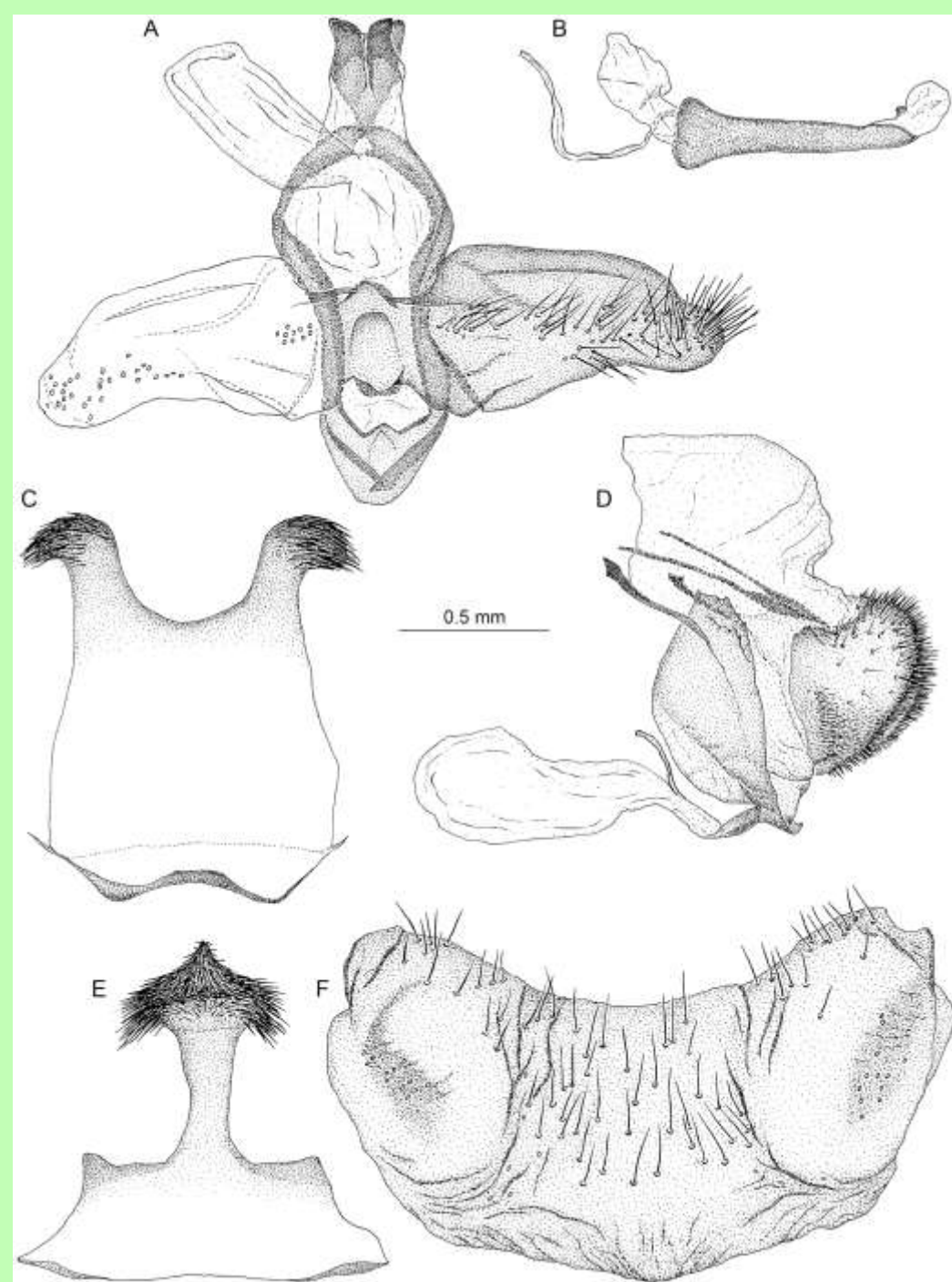
Dave Wagner



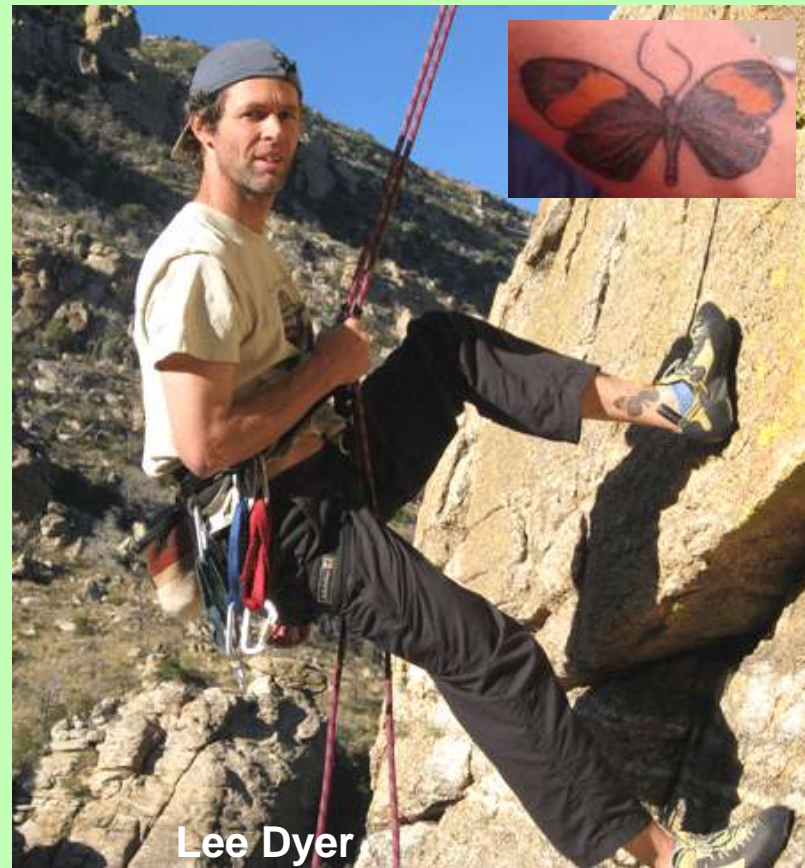
Nebulosa elicioi Miller, 2009



Elicio Tapia



Stenoplastis dyeri Miller, 2009



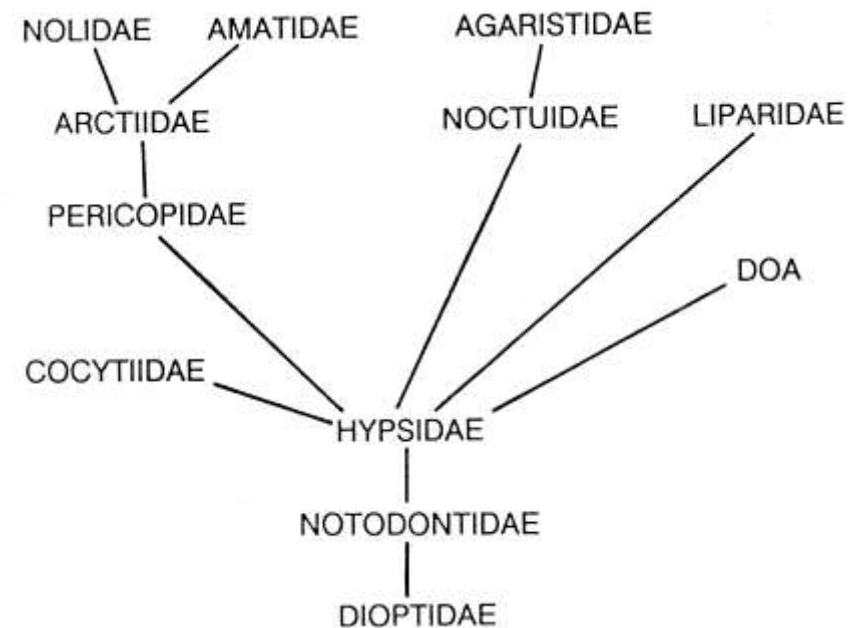
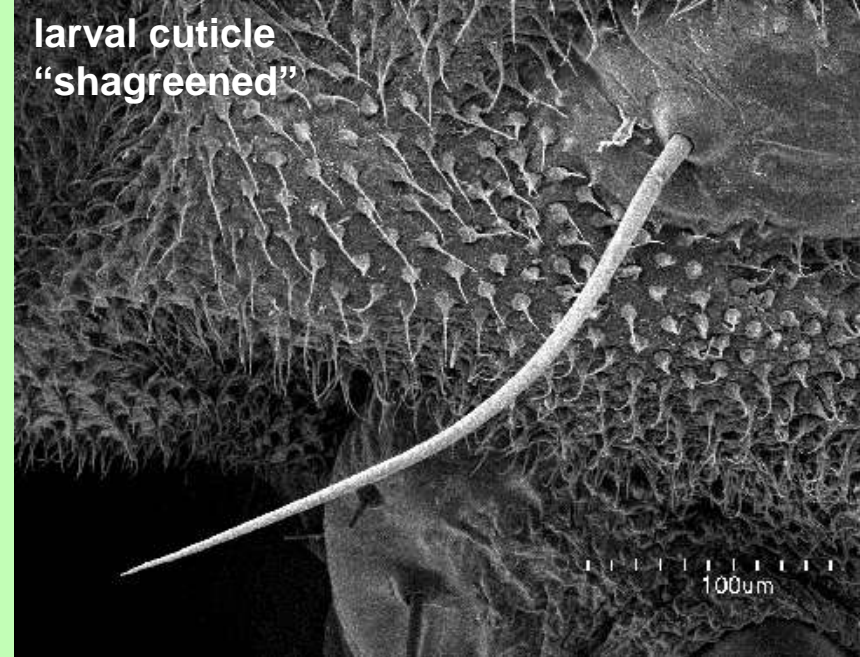
Lee Dyer



***Phryganidia californica* Packard**
"The California Oak Moth"



Miller, J.S. (1987) A revision of the genus *Phryganidia* (Lepidoptera: Dioptidae), with description of a new species. Proc. Entom. Soc. Washington 89: 303-321.



Superfamily Noctuoidea (Forbes, 1923)



***Josia
insincera***



Rosema deolis



***Bardaxima
perses***



***Crinodes
besckei***

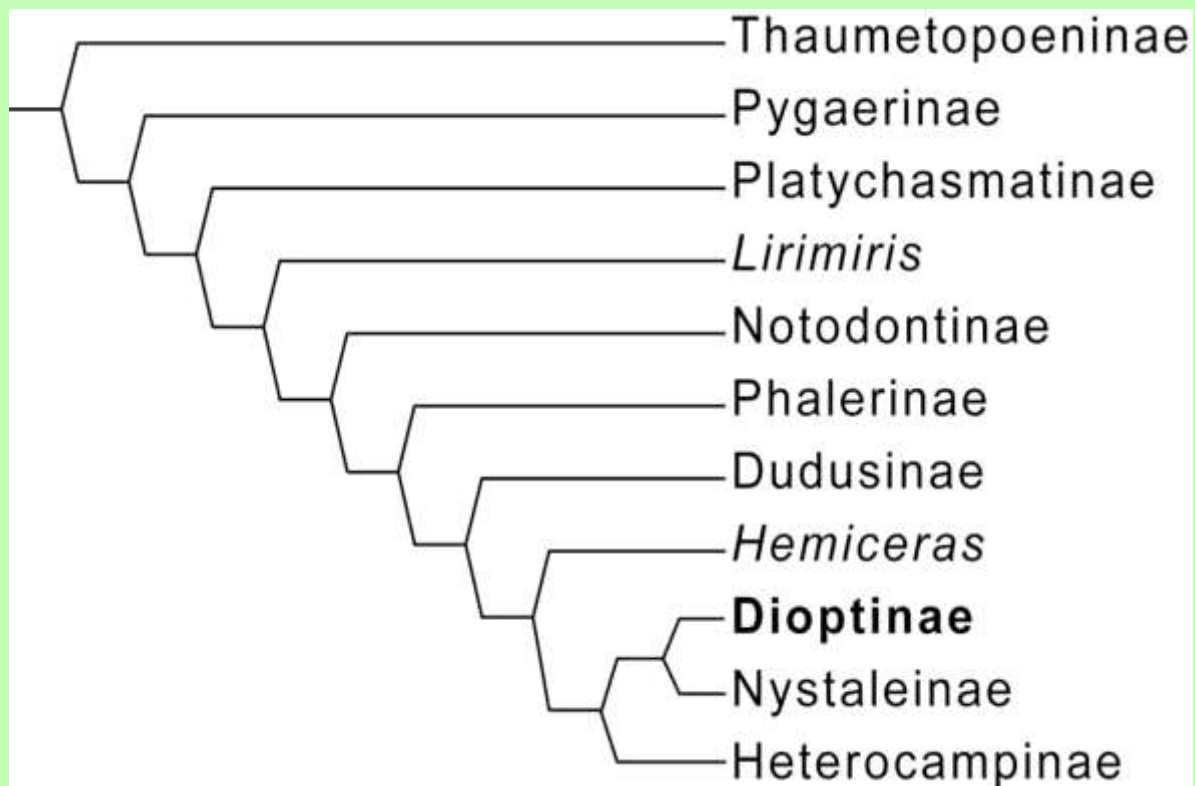


Lirimiris fascis



***Nystalea
ocellata***

- 52 exemplar species chosen to represent all subfamilies and tribes of the Notodontidae.
- 6 members of the “Dioptidae” included in the analysis.
- 13 species from the Lymantriidae, Arctiidae and Noctuidae used as an outgroup.



Miller, J.S. (1991) Cladistics and classification of the Notodontidae (Lepidoptera: Noctuoidea) based on larval and adult morphology. AMNH Bulletin, 204: 1-230.

- “Dioptidae” are a derived, diurnal subfamily of the Notodontidae.
- subfamily Nystaleinae (350 spp., all Neotropical) is the sister group to the Dioptinae.



Dioptis uniguttata
(Dioptinae: Diopitini)



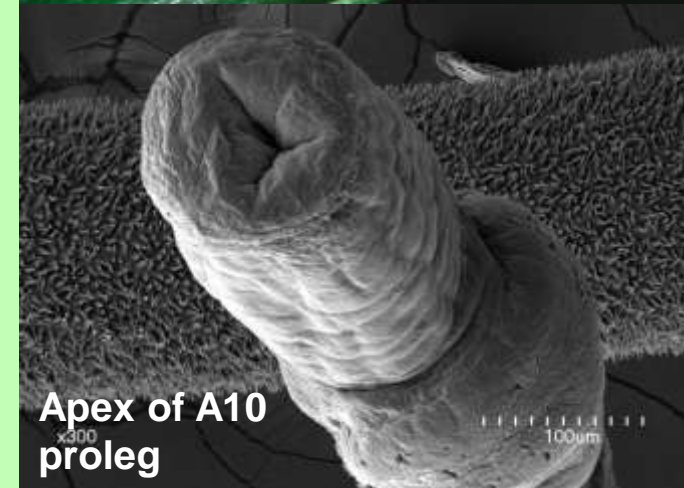
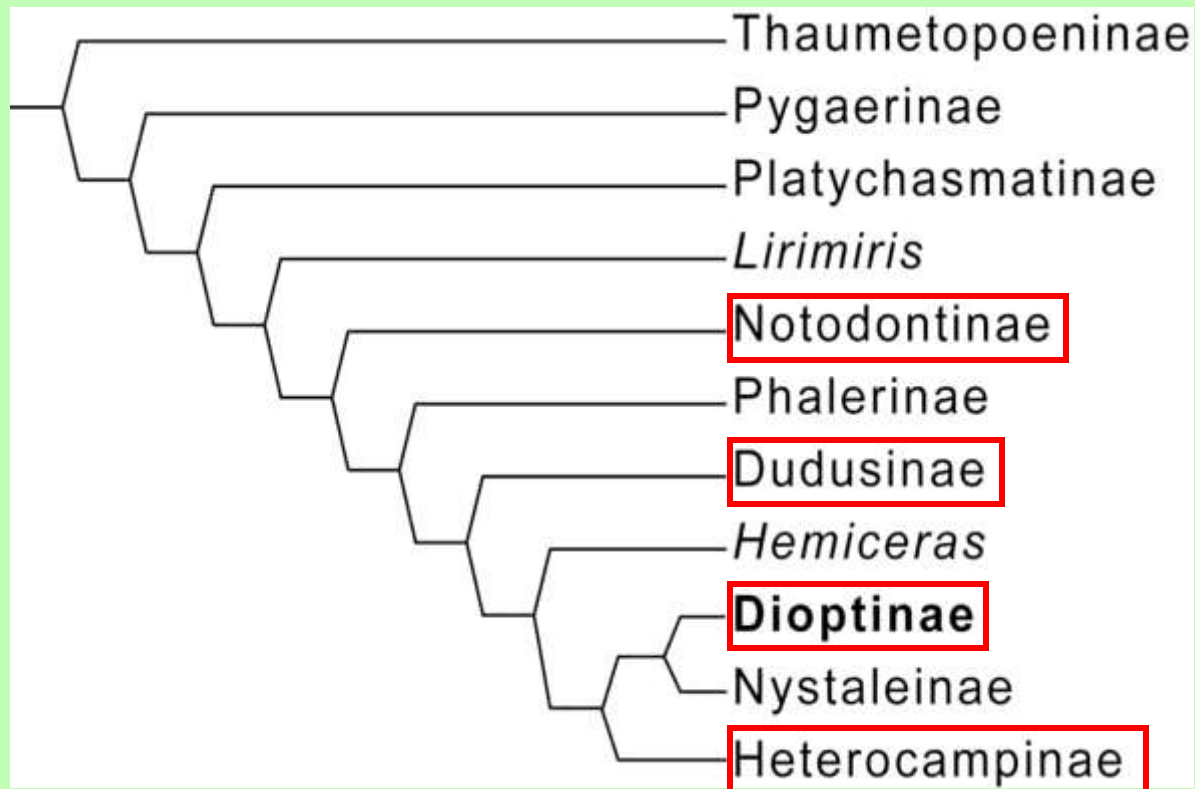
Scea superba
(Dioptinae: Josiini)



Lepasta majorina
(Nystaleinae)



Farigia gammara
(Heterocampinae)



- stemapods have apparently evolved separately in four subfamilies of the Notodontidae.
- in each case they occur in derived members of the respective subfamily.

“Homoplasy Happens”



Diopsis uniguttata Warren



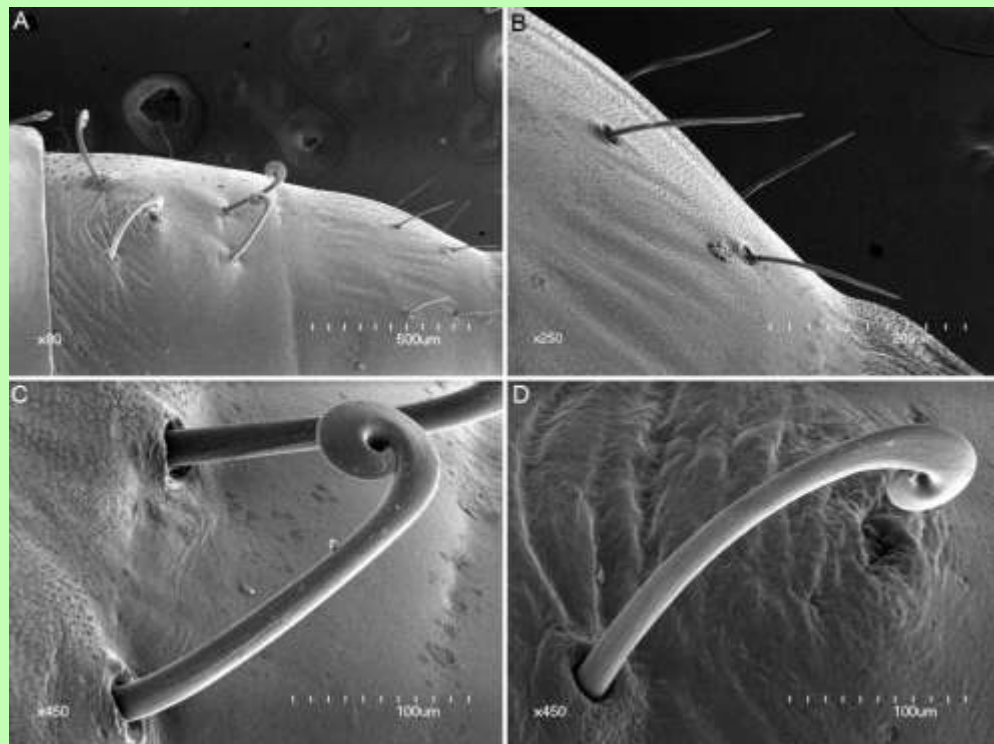
Polypoetes forficata Miller



Nebulosa erymas (Druce)



Erbessa pales (Druce)



- hook-shaped setae on A8-9 of pupa.

Steve's apartment
21st floor
10th Ave & 43rd St



north



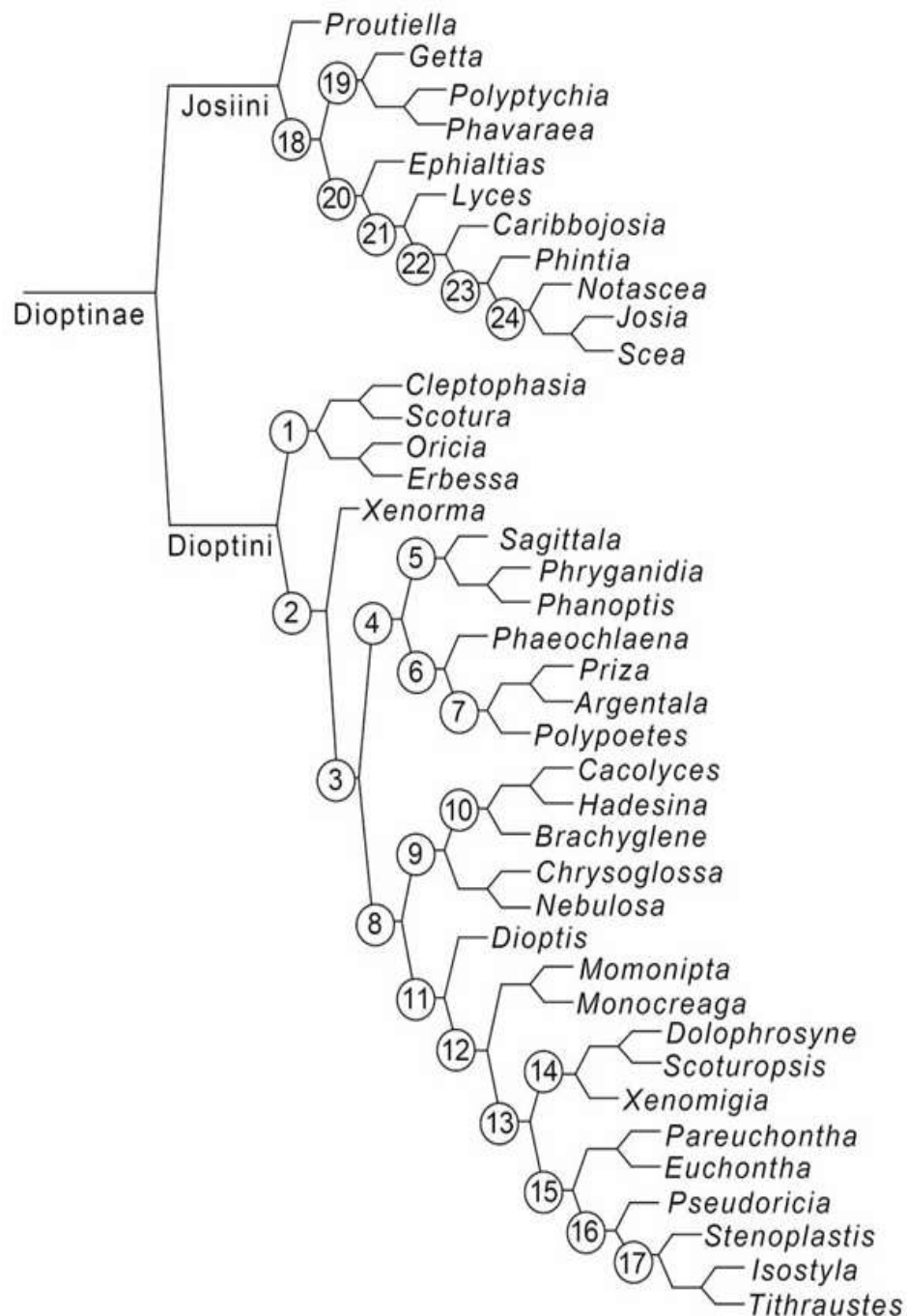
west





*"Papilio
polyxenes goes
to town."*

July, 2009



Dioptine host plant evolution mirrors patterns found in butterflies.

Order Malpighiales:

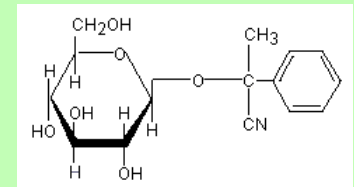
Passifloraceae – *Passiflora*

Turneraceae – *Turnera*

Violaceae – *Rinorea*, *Hybanthus*

Achariaceae – *Lindackeria*

- host plants for the Dioptinae, as well as for butterflies in the subfamily Heliconiinae; all produce cyanogenic glycosides.





Hybanthus concolor



Oricia truncata larva



Argynnis paphia
(Heliconiinae, France)

5 dioptine genera (~ 35 spp.)
associated with Violaceae.



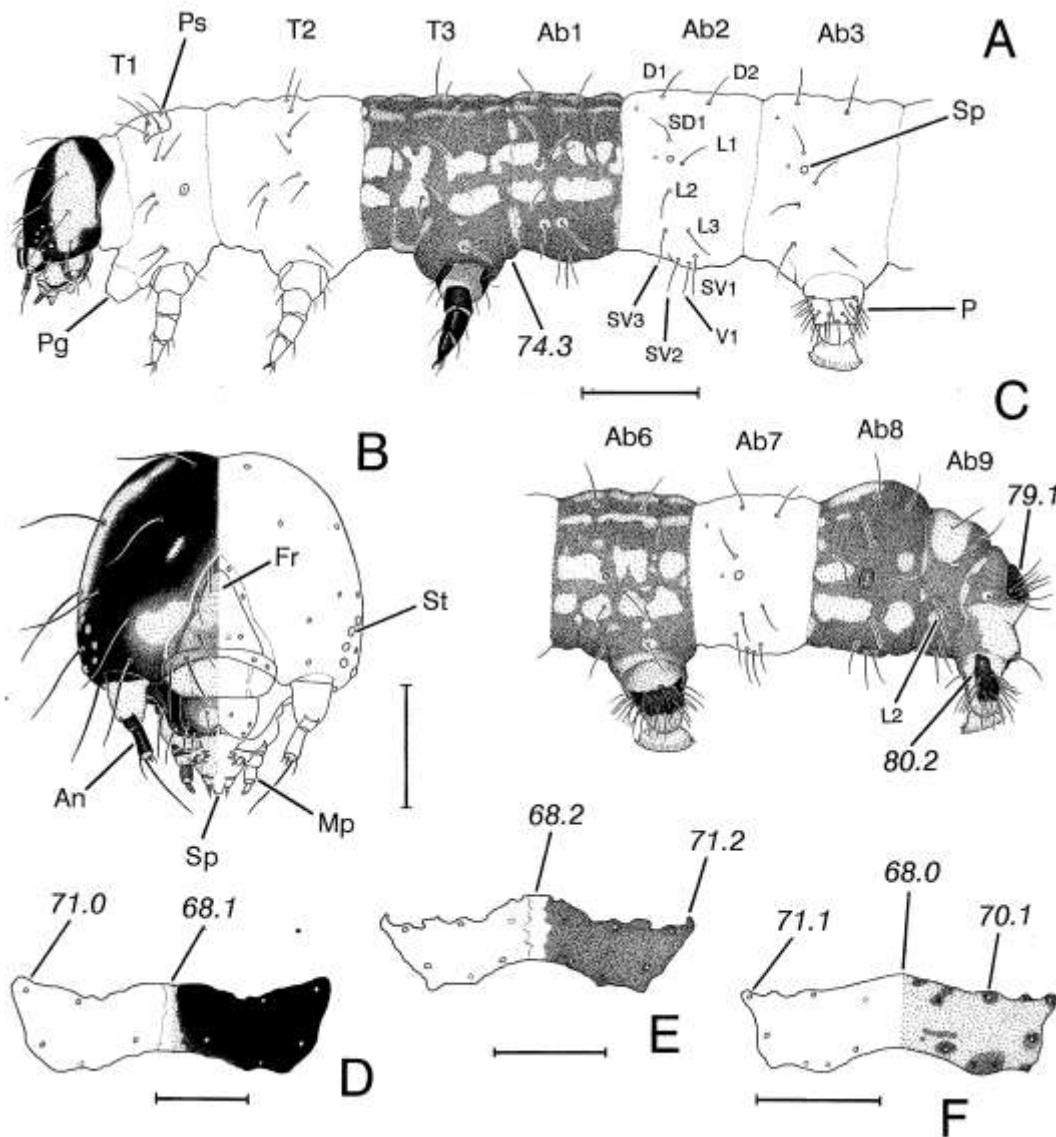
Oricia truncata
(Costa Rica)



Scotura annulata
(Panama)



- two lepidopteran clades associated with Passifloraceae – the Heliconiinae (110 species) and Josiini (105 species).
- genus *Passiflora* contains 450 species worldwide, 430 in the New World tropics.
- *Passiflora* is currently divided into 8 subgenera (Yockteng & Nadot, 2004).

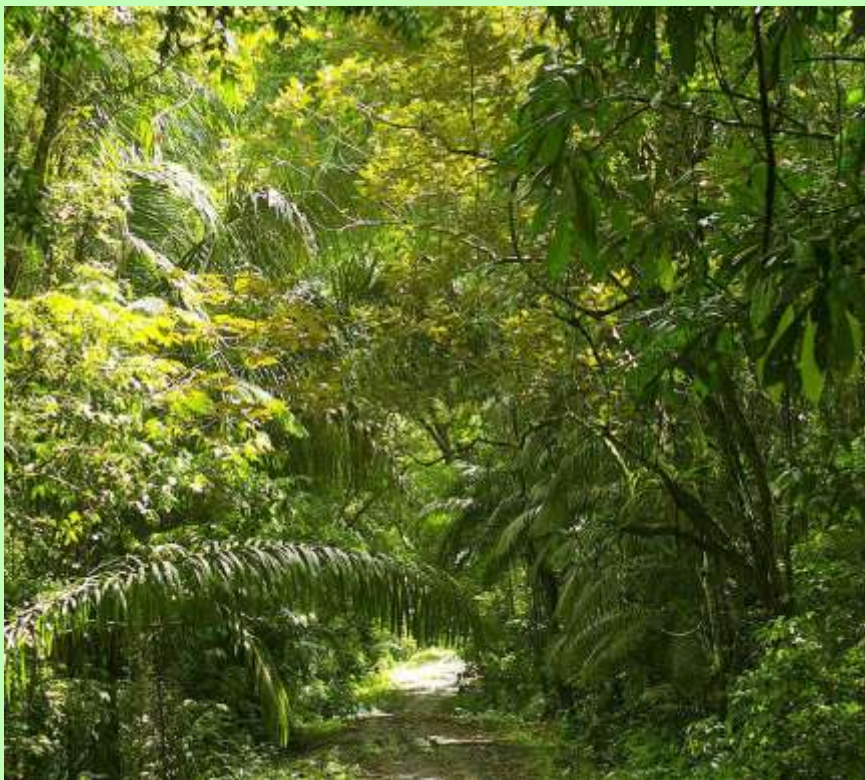


head surface sculpture



tarsal setae

Caterpillar structure in the Josiini (from Miller, 1996); 74 characters from larval morphology.



Pipeline Road, Panama (50 m)



Host plant:
Turnera panamensis
(Turneraceae)



Ephialtias draconis Druce, 1885





Río Cariblanco, Heredia, Costa Rica (750m)



Host plant: *Passiflora tica* (subg. *Astrophea*)



Getta tica Miller, 2009



Río Quijos, Napo, Ecuador (1900m)



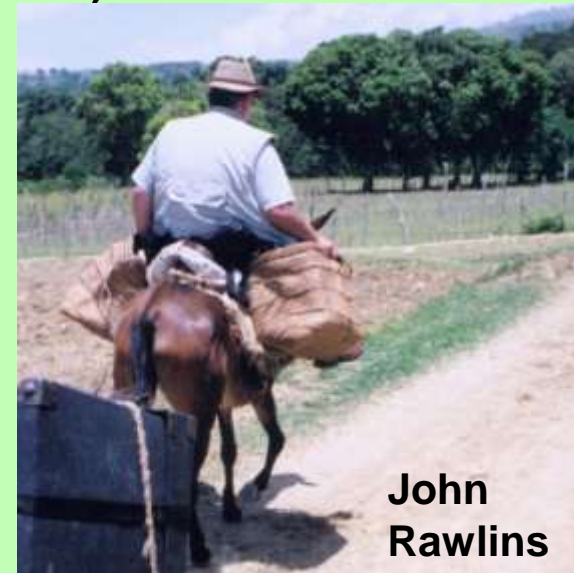
Host plant: *Passiflora* sp. nov.
(subg. *Tacsonia*)

Scea superba Druce, 1890





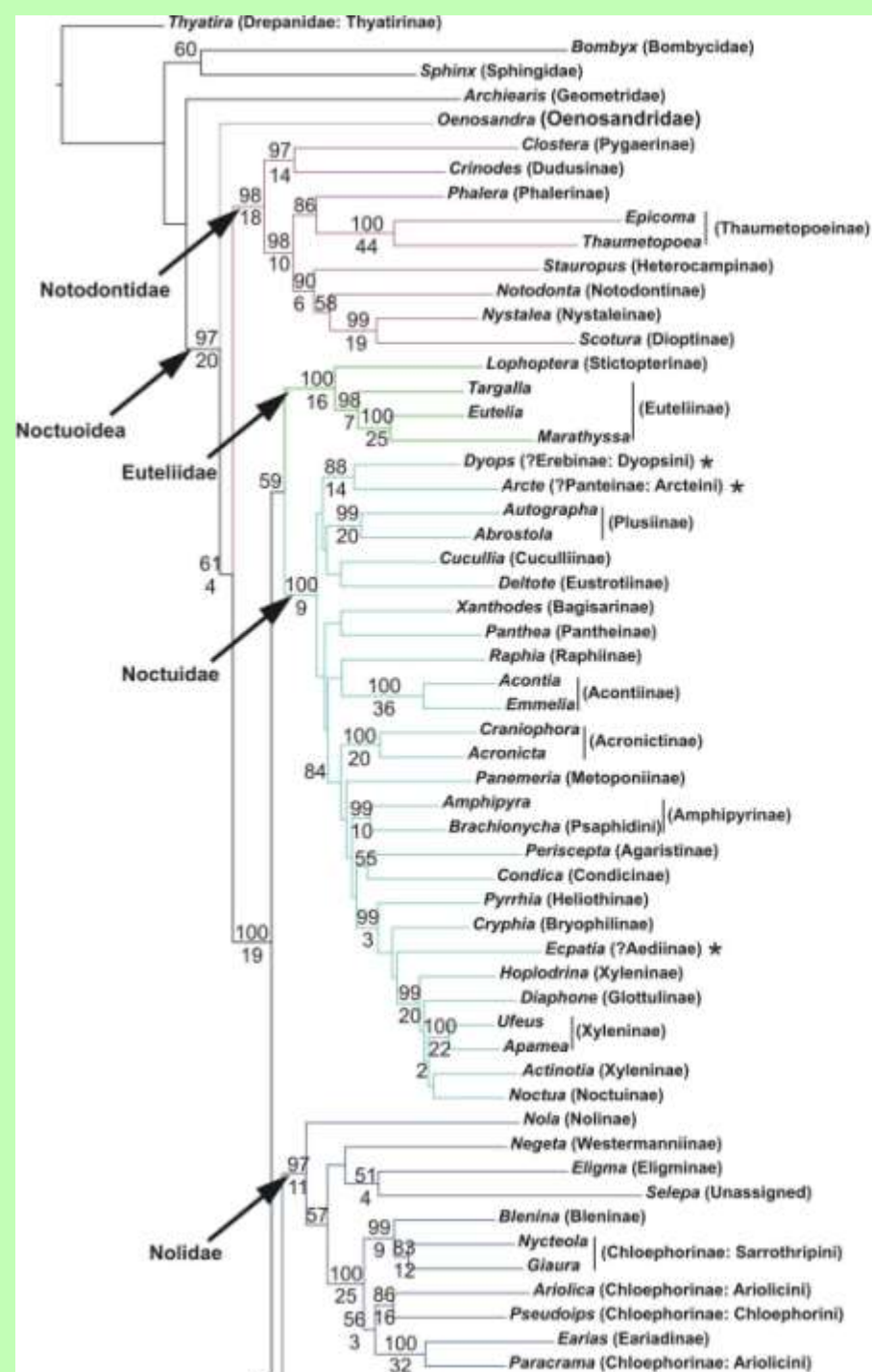
Sierra de Neiba, Dominican Republic (1780m)



**John
Rawlins**



Caribojosia youngi Rawlins & Miller, 2008
Host plant: *Passiflora sexflora* (subg.
Decaloba)



From: Zahiri, R., I.J. Kitching, J.D. Lafontaine, M. Mutanen, L. Kaila, J.D. Holloway & N. Wahlberg (2010) Dispersing the mist: molecular phylogenetics of Noctuoidea (Insecta: Lepidoptera). Molecular Phylogenetics & Evolution [in press].

- 150 noctuoid exemplars (representing 70,000 spp.).

- 6407 bp DNA from 8 genes.

Corroborates Miller (1991):

- Notodontidae arise above Oenosandridae at the base of the noctuoid phylogeny.

- support for a sister group relationship between Dioptinae and Nystaleinae.

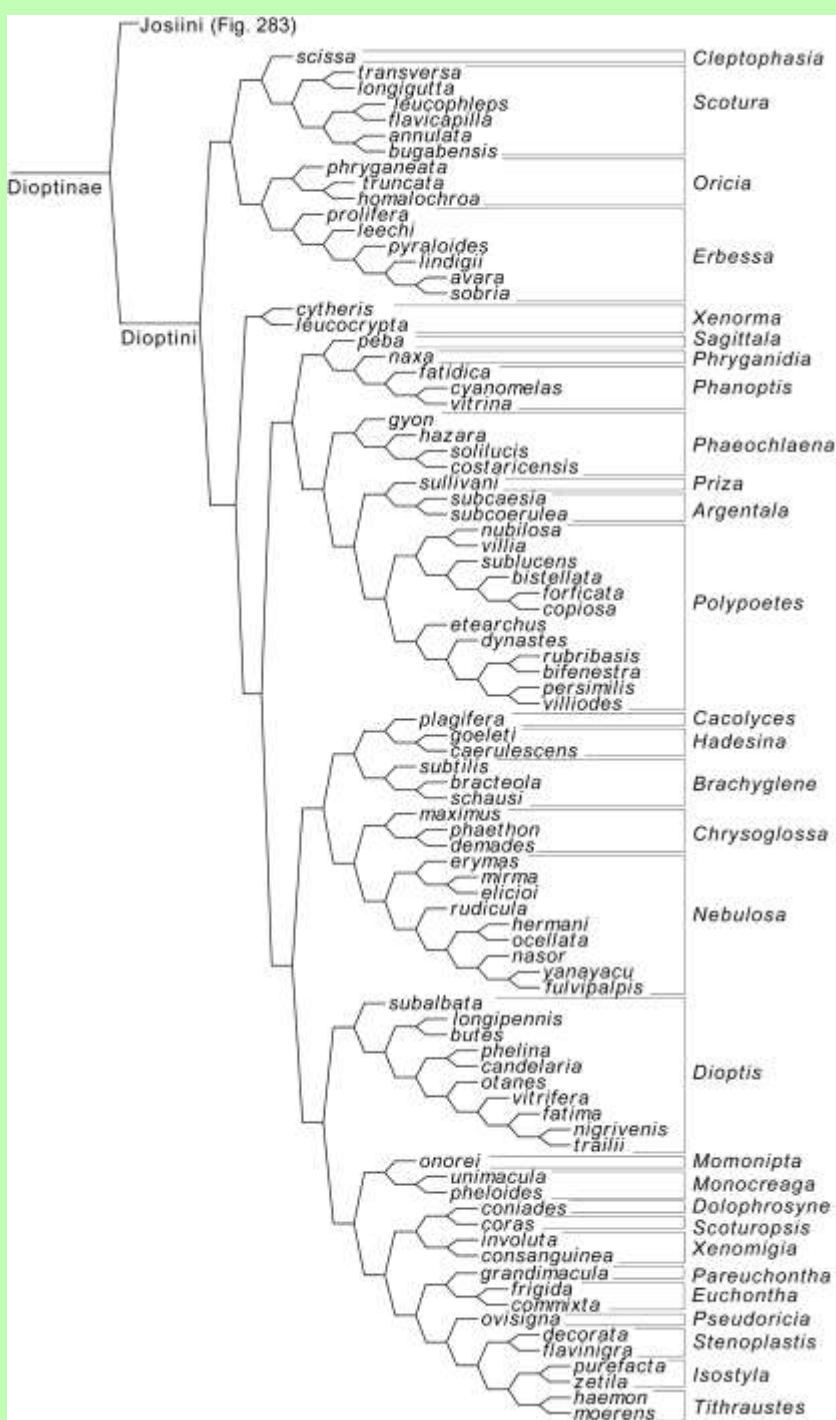


- Monophyly of the subfamily Diptinae is strongly supported; 19 synapomorphies – 7 from larvae and 12 from adults (Miller, 1991).
- The Neotropical subfamily Nystaleinae is the sister group to the Diptinae.
- Generic boundaries in the most recent classification (Bryk, 1930) were a shambles.

Goals:

- 1) Establish monophyletic genera for the Diptinae based on adult morphological characters.
- 2) Provide a means for identifying the genera & species.
- 3) Provide a summary of the group's biology.





- After 2 years of comparative study, 115 dioptine exemplars chosen to represent structural diversity across the subfamily.

- 305 adult morphological characters delineated by 938 character states.

- parsimony analyses produced a single tree; served as the basis for a revised classification of dioptine genera.

- all described species were assigned to one of the newly circumscribed genera (10 species remained incertae sedis).

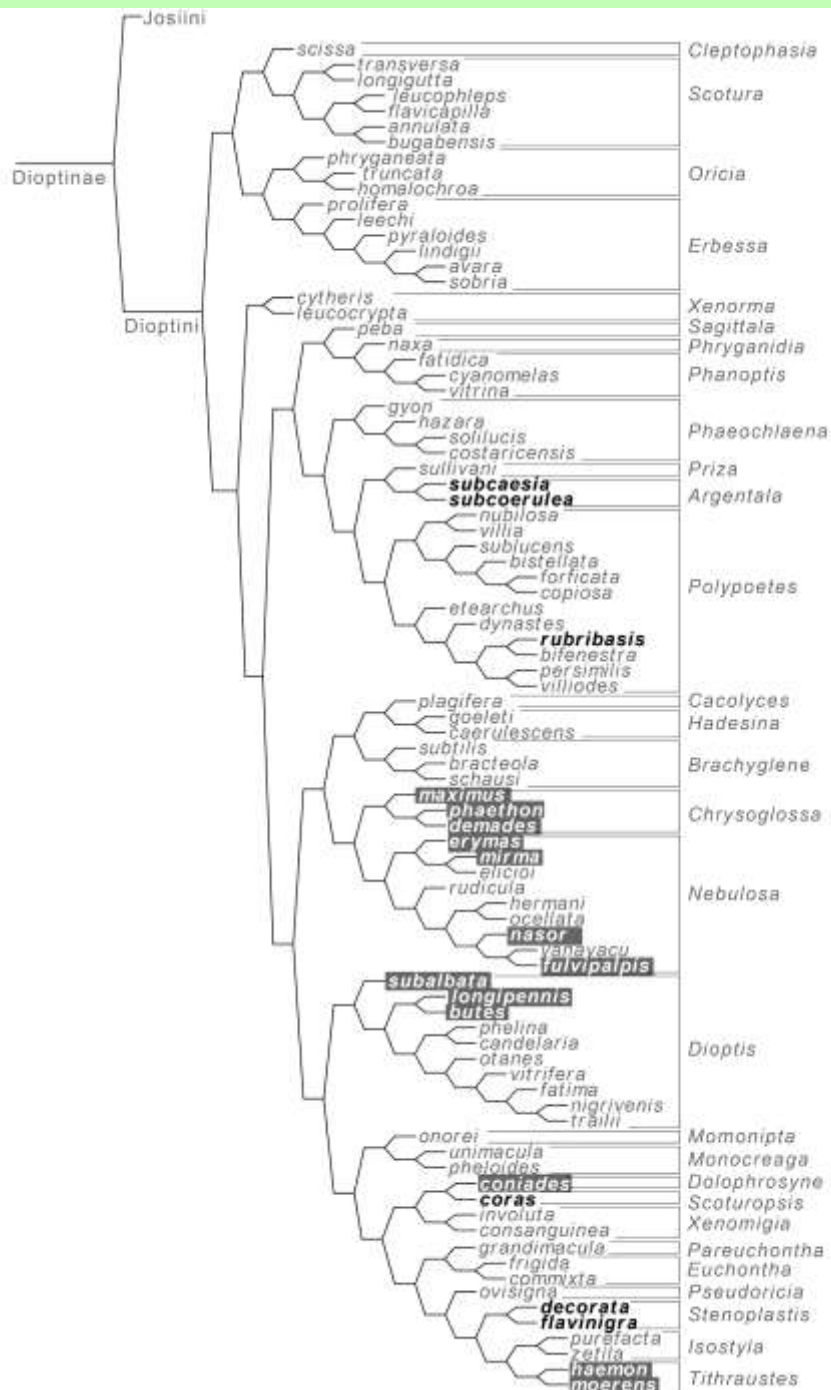
Intergeneric relationships:

- add characters from DNA and immature stage morphology.



Miller, J.S. (2009) Generic revision of the Dioprinae (Lepidoptera: Noctuoidea: Notodontidae). Bulletin of the American Museum of Natural History, 321: 1-1022.

- 456 species in the Dioprinae (64 newly described); estimated total of 700-800 spp.
- 43 genera (7 new) placed in two tribes – the Dioptrini and Josiini.
- 118 new combinations.
- All species illustrated and identification keys provided.
- Known life history data summarized.



***Tithraustes haemon* Druce**

E.g. of new taxonomic combinations:

- genus *Tithraustes* of earlier authors contained 42 species.
- in Miller (2009), 35 of these are dispersed to 5 different diopline genera.
- 1 goes to the Arctiidae.
- *Tithraustes*, now monophyletic, contains only 10 species.

Evolutionary parallels between Dioptinae and butterflies:

- 1) Larvae associated with toxic host plants.
- 2) Adults involved in mimicry complexes.
- 3) Sound production in males.
- 4) Evolution of complex androconial systems.



photo J.S. Miller

***Polypoetes nubilosa* (Warren)**
(Pichincha, Ecuador)



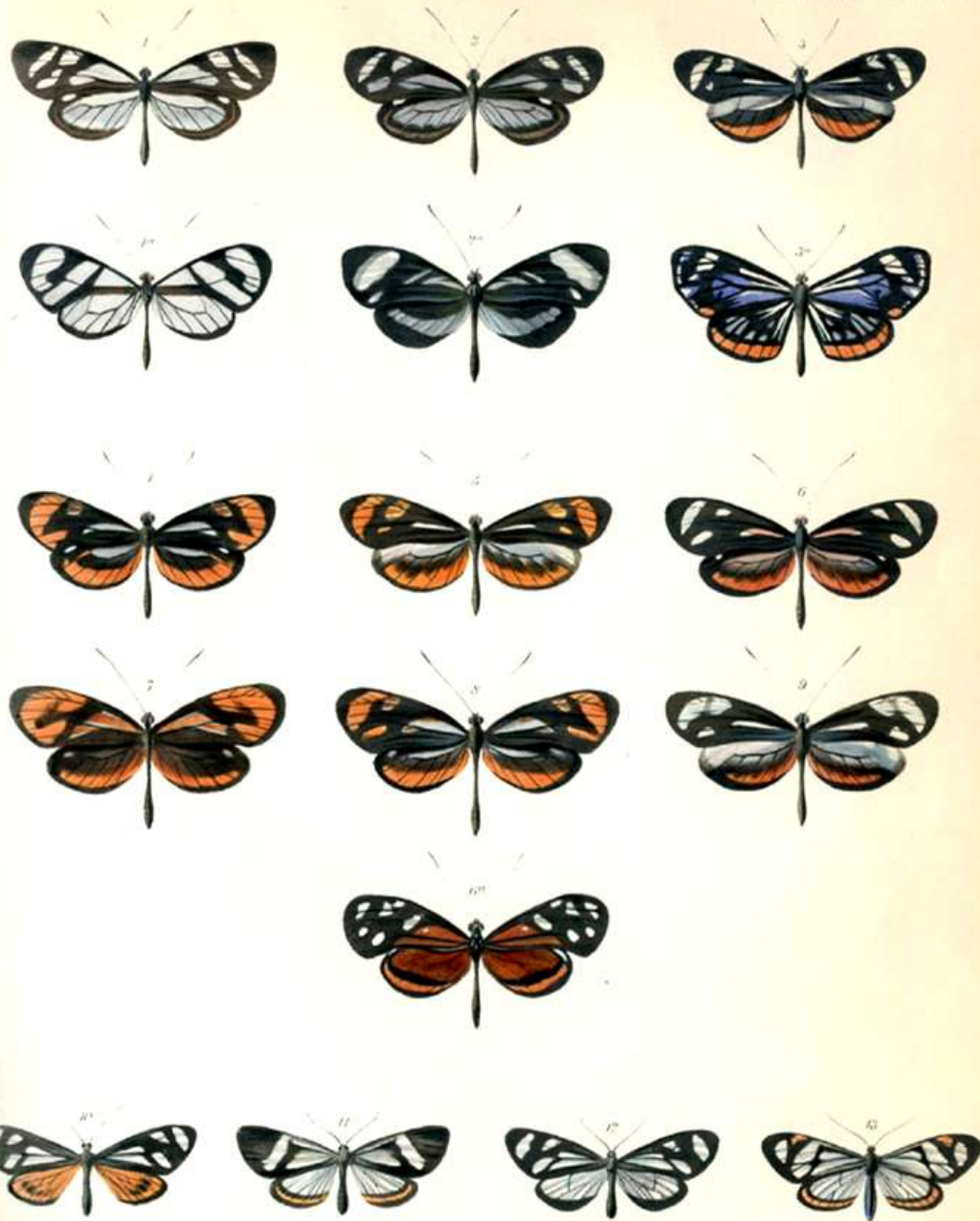
photo Andrei Sourakov

***Scea auriflamma* Hübner**
(Bahia, Brazil)



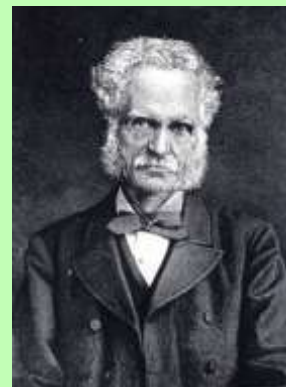
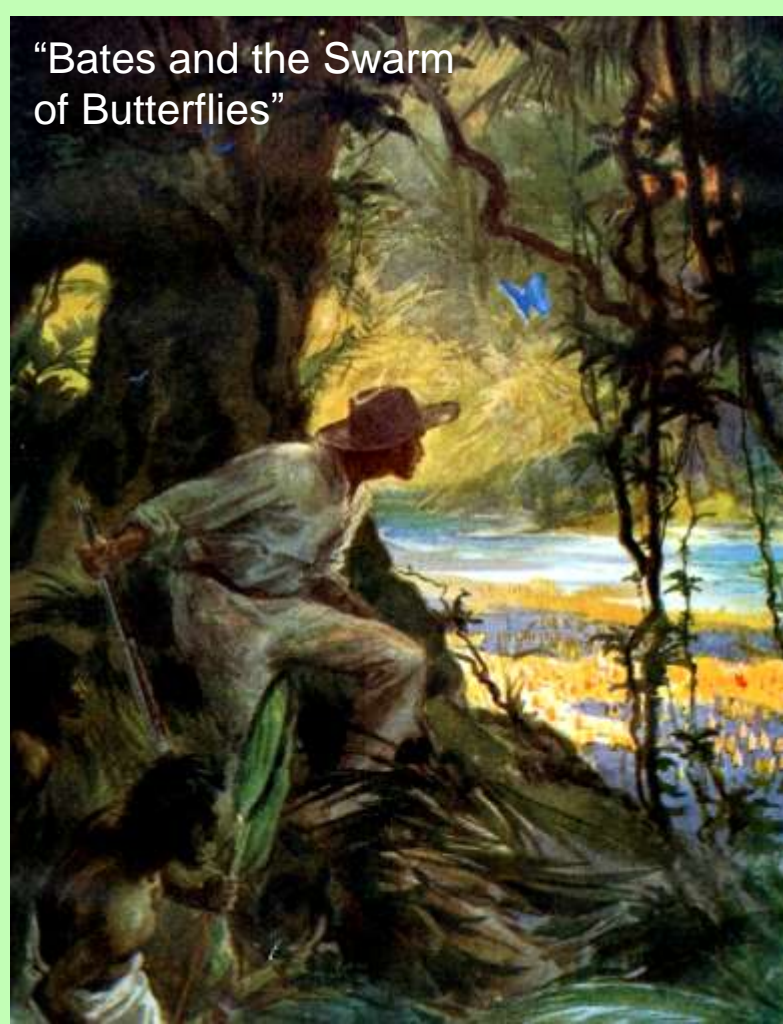
photo Will Carter

***Dioptis vacuata* Warren**
(Darién, Panamá)



From: H.W. Bates (1862)

"Bates and the Swarm of Butterflies"



From: Arthur Twidale (1920) *Beautiful Butterflies of the Tropics*.

Pacific Ocean

Colombia

Pasto

Mocoa

Esmeraldas

Western species:

Lyces striata (Dioptinae)

Crocomela erectistria (Pericopinae)



QUITO

Baeza

Río Napo



Eastern species:

Lyces longistria (Dioptinae)

Crocomela nr. erectistria
(Pericopinae)

Babahoyo

Puyo

Sarayacu

Guayaquil

Río Pastaza

Cuenca



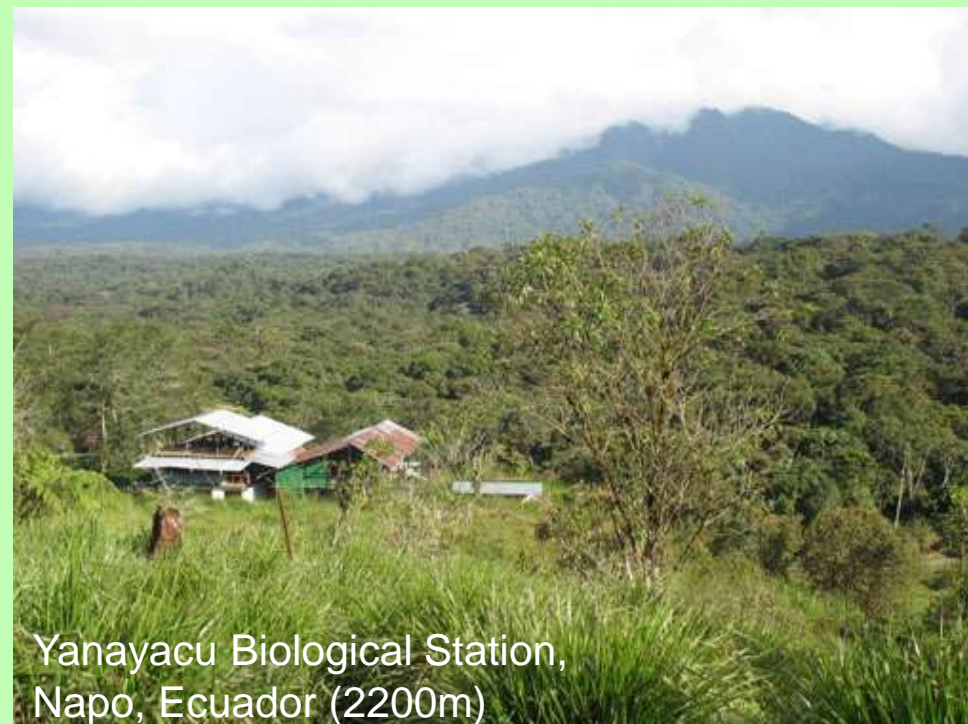
Estación Pitilla, Guanacaste,
Costa Rica (700m)



Dan Janzen



Harold
Greeney



Yanayacu Biological Station,
Napó, Ecuador (2200m)



Erbessa pales Druce
(Ecuador)



Miconia sp.
(Ecuador)

- genus *Erbessa* (60 species); most associated with Melastomataceae.



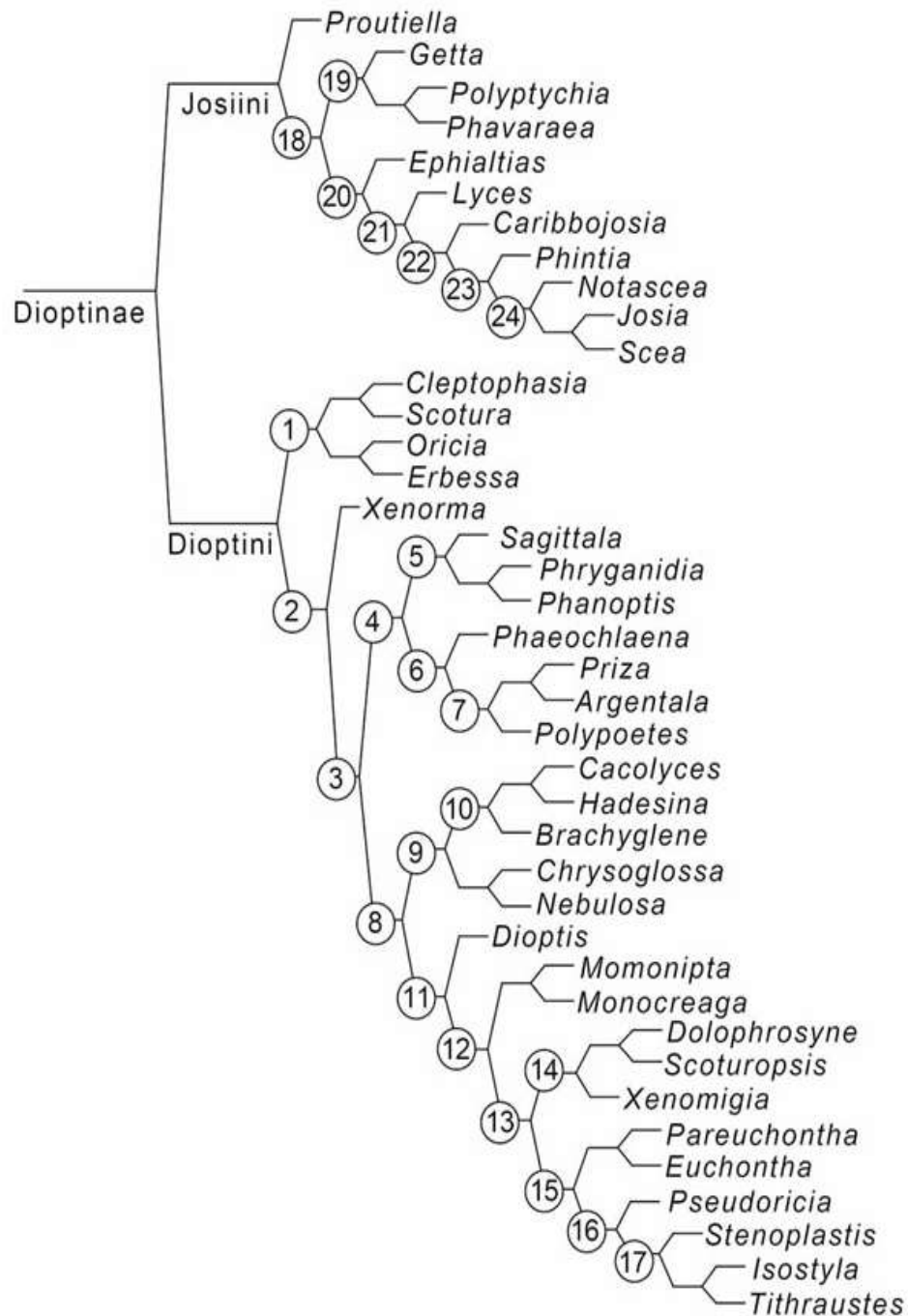
Erbessa regis (Hering)
(Peru)



Erbessa albilinea Miller
(Costa Rica)



Erateina drucei Thierry-Mieg
(Geometridae, Ecuador)



- 7 dioptine genera (totaling 120 species) are associated with monocots; palms & bamboo.



***Tithraustes noctiluces* (Butler)
(Costa Rica)**





Yanayacu Biological Station,
Napó, Ecuador (2200m)

Butterfly subfamily Satyrinae (Nymphalidae):

- 2,400 described species, most associated with monocots (banana, bamboo & palms).
- many undescribed cloud forest pronophilines associated with *Chusquea*.
- Pronophilini co-occur with *Xenomigia*.



Euptychoides nossis
(tribe Pronophilini)



Caligo atreus
(tribe Brassolini)



San Rafael, eastern
Ecuador (1400m)

~ 70 species in 4 dioptine genera are associated
with understory palms (Arecaceae).



***Dioptis
uniguttata***
Warren



Geonoma orbignyana





Papallacta, Ecuador (4000m)



Chusquea sp. nr. *scandens*

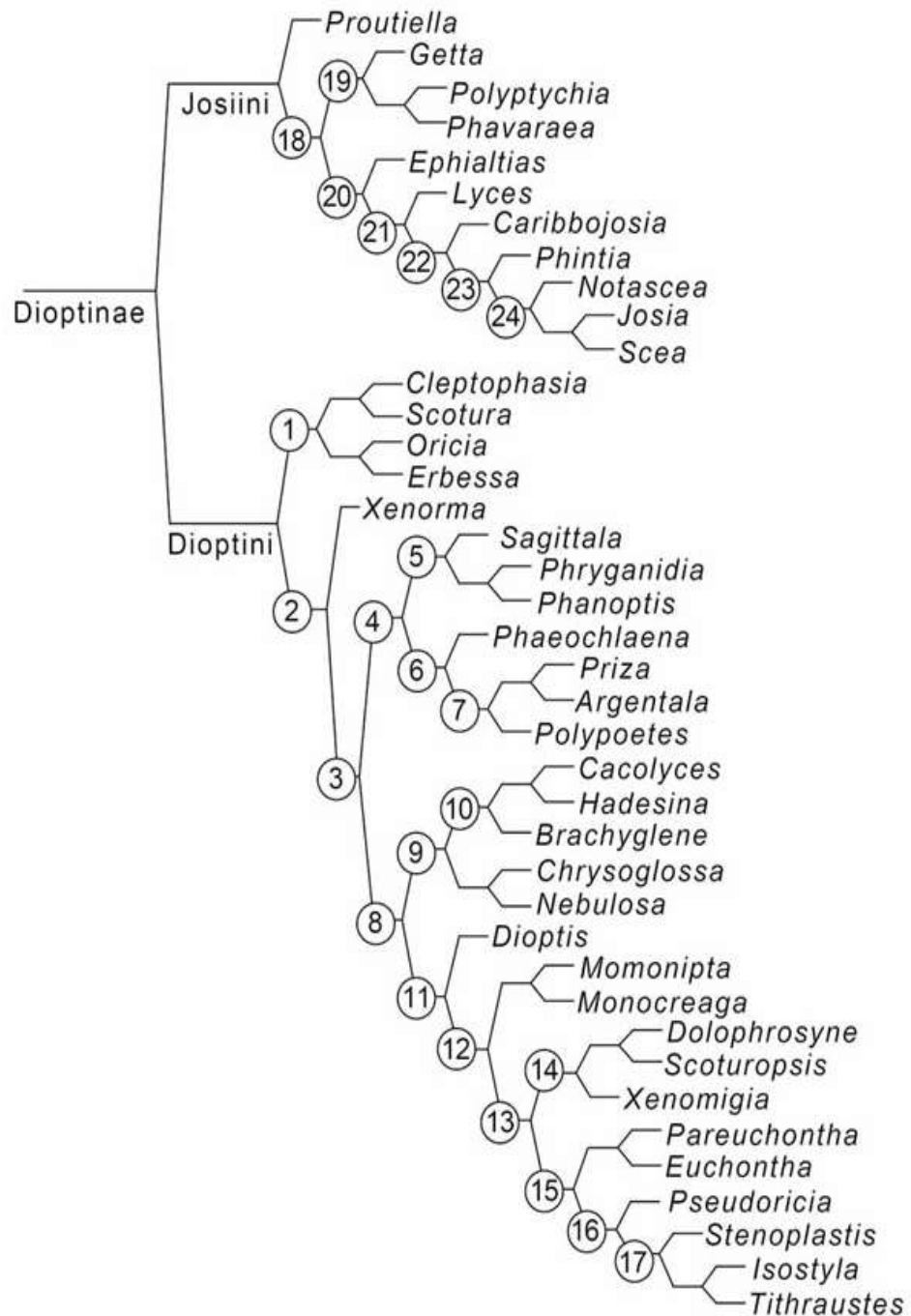
~ 50 cloud forest species in 4 genera are associated with *Chusquea* (Poaceae); all nocturnal.



Xenomigia involuta Miller, 2009 (western Ecuador)



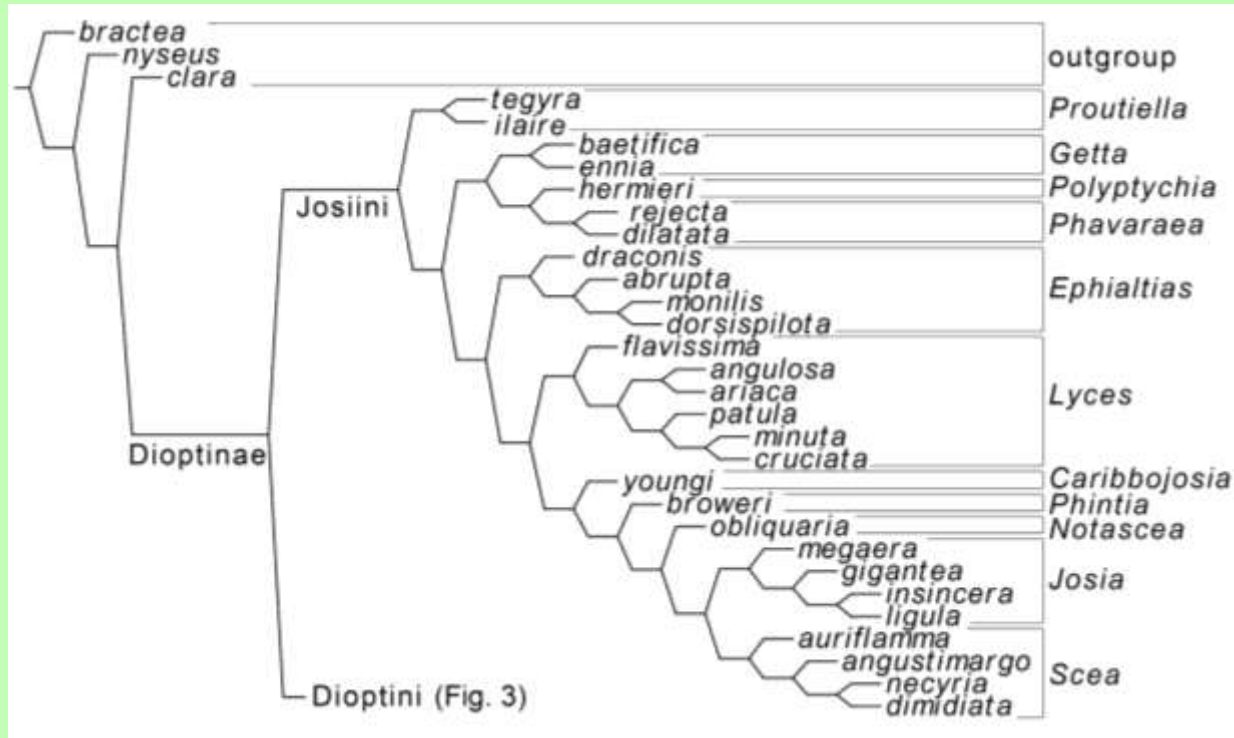
Xenomigia brachyptera
Sattler & Wojtusiak, 2000
(western Venezuela)



***Nebulosa huacamayensis* Miller**
 Host plant: ***Casearia* (Salicaceae)**



Miller, J.S., A.V.Z. Brower, & R. DeSalle (1997) Phylogeny of the neotropical moth tribe Josiini (Notodontidae: Dioptinae): Comparing and combining evidence from DNA sequences and morphology. *Biol. J. Linn. Soc.* 60: 297-316.



Proutiella ilaire (Druce)



Notascea obliquaria (Hübner)



Phintia broweri Miller

- host plants known for 31 josiine species in 7 genera (~30% of tribe).
- life histories for critical taxa remain to be discovered; most occur in eastern Brazil or the Amazon Basin.
- compare the details of host plant evolution in the Heliconiinae and Josiini.



***Phaeochlaena hazara* (Butler)**



Erbessa salvini Felder



Pitilla, Costa Rica (700 m)

- 1) During the course of notodontid evolution, one clade seems to have “jumped the tracks”, giving rise to the Dioptinae.
- 2) That jump – possibly initiated by larval adaptation to secondary plant chemicals – has produced remarkable parallels between Dioptinae and butterflies involving their ecology, behavior & morphology.
- 3) These similarities offer the potential to address a wealth of evolutionary questions.



Yanayacu Biological Station, Napo, Ecuador (2200m)

- 66 species of Notodontidae in 4 subfamilies occur at YBS.
- 9 dioptine species were described in Miller (2009).
- 28 species being described by Miller & Thiaucourt (2010, in prep.).
- 56% of the notodontid fauna will have been described since 2009.



***Dognina inermis* Miller, 2010**
Host plant: *Miriocarpa* sp.
(Urticaceae)



Future Research:

- 1) Re-visit relationships among dioptine genera; add data from immature stages and DNA; investigate wing pattern evolution and host plant relationships.
- 2) Species level analysis for the Josiini; compare the evolution of *Passiflora*-feeding in Josiini and Heliconiinae.
- 3) Document the Notodontid fauna of North America (to be published in the *Moths of North America* series); 137 described species, 25 new.
- 4) Revise the generic classification for New World Notodontidae (1500 described species); continue building our knowledge of biodiversity and evolution in this remarkable moth group.



Heterocampa biundata
(New York)